

## OTHER PUBLICATIONS

- [1] Car-Magazine ADAC 1/95
- [2] Car-Magazine AMS (Auto Motor und Sport) 23/97
- 5 [3] Car-Magazine AMS 12/99, Newspapers Wiesbadener Kurier of 28.12.98, 20.01, 22.06,  
04.11.99, Frankfurter Allgemeine Zeitung of 08.09.99, Frankfurter Rundschau of  
12.06.99
- [4] Wiesbadener Tagsblatt of 28.12.97 reporting 100 injured passengers, 10 of which  
severely, during turbulence-related vibrations of an aeroplane Boeing 747.
- 10 [5] Wiesbadener Tagsblatt of 15.04.99 reporting 30 injured passengers during turbulence-  
related vibrations of an aeroplane Boeing 747.
- [6] Police accident report and photos documenting the steering wheel and -column totally  
deformed by the head, thrown forward, of a 34 years-old driver of a brand-new German  
luxury car.
- 15 [7] Police accident report and newspaper documenting the instant death of a 21 years-old  
female driver in a German car, crashing into a larger German car on an urban road, due  
to the head impact with the window pane.
- [7] Police accident report and accident report by Go documenting the instant death of a 34  
year-old female driver in a German premium sport car, into which a smaller Japanese car  
crashes in the city Wiesbaden, due to the head impact with the window pane and  
whiplash.
- 20 [8] 34-page accident report by Go concerning severe/fatal injuries, submarining, head impacts  
and whiplash resulted from failure of conventional seat belts etc. to four German  
Ministers, General Attorney, Vice General Attorney, Senior Attorneys, Police Chief  
Directors, Police Directors etc.
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## SHOULDER- AND NECK HOLDER

### CROSS REFERENCE TO RELATED APPLICATIONS

This is an international application number PCT/DE98/03271 (WO 99/24292, European Patent EP 1 037 771 B1, German Patent DE 197 58 498 C2) filed Nov. 10, 1998 and claiming the priority of DE 197 58 498 A1 filed Nov. 11, 1997.

#### 1. Field of the Invention:

The present invention relates generally to a shoulder- and neck holder, which restrains the shoulders and neck of a belted passenger, an anti-submarining seat-belt assembly as well as a safety seat in order to dampen vibrations and substantially reduce the acceleration-depending loads below the injury-related values

- in an event of arbitrary accident of a vehicle, train or an aeroplane or
- in an inflight turbulence.

#### 15 2. Discussion of the Related Art:

It is known in the prior art to provide

- a three-point seat belt (safety belt or lap-shoulder seat belt) consisting of a shoulder belt extending across the torso and of a lap belt extending across the lower part of body in motor vehicle;
- a two-point seat belt acting as lap belt extending across the lower part of body in an aeroplane or a rear seat of vehicle or
- a seat-belt substitute for restraining the shoulders, upper part of the body and/or neck.

In order to formulate in single terminology a generalized definition for the proper term is presented:

*"belt portions 1.1, 1.2, 1.3 and 1.4"* for members of a multi-point seat belt **1a to 1d** (Figs. 1, 14) ref. to EP 1 037 773 B1 (WO 99/24294, PCT/DE98/03270, DE 197 49 780 C2). The upper part of body is restrained by extending the shoulder belt portions **1.1, 1.2** crosswise in an „X-shape” while the lower part of body is restrained by the lap belt portion **1.3**.

*"belt portions 1.2, 1.3 and 1.4"* for members of a three-point belt **1e** to restrain the upper part of body and to restrain the lower part of body, shown in **Fig. 14**;

*"belt portion 1.3 "* for conventional two-point or lap seat belt;

*"floor 6"* for vehicle-, train- or aeroplane floor (**Fig. 14**);

*"seat frame"* for frame of seat backrest or seat-cushion;

*"accident"* of a vehicle, train or aeroplane for front-, side-, rear collision of a vehicle or pile up (mass accident) or for train-, aeroplane accident or turbulence-related vibrations of an aeroplane;

*"energy-absorption"* for absorption and release of impact energy as well as dampening vibrations;

*"undampened energy-absorption"* for absorption and release of impact energy while vibrations are undampened;

5 "energy-absorbing method" for gradually absorbing subenergies „ $\Delta F_i$ ”, the addition of which is equal to total energy „ $F_n$ ” or belt force (Fig. 9) and the increment  $i$  of which increases from 1 to  $n$ , below the respective injury-related values by undampened energy-absorption, energy-absorption, preserving the clamping and friction forces of control-clamping elements associated with the fracture of the sites of predetermined fracture of clamping elements and energy absorbers during the energy-absorption, thus enhancing the survival chance and ensuring the restraint below the tensile strength of seat belt.

10 It is well known to restrain passengers, particularly, of vehicles with seat belts in the event of accident, where a small forward motion of the upper part of body at low speed is acceptable. However, in the crash tests at speed of 55 km/h the rotating masses of torso 95.2 and head 95.1 are thrown forward and twisted by the acceleration-dependant loads [1, 2, 6 to 8].

15 Due to lack of restraint systems in trains passengers are not restrained, thus subjected to severe or fatal injury when ejected from the seats in accidents.

It is well known to restrain passengers of aeroplanes by two-point or lap seat belts, which are incapable of restraining the upper part of body as well as head in accidents, particularly associated with sudden turbulence. Consequently, severe/fatal injuries have been reported and, for sure, will be reported in the future.

20 Ref. to US 2,833,554 a passenger, sitting on the seat, is restrained by a head shielding plate, chest shielding plate and at least one knee shielding plate, all of which are provided with arms pivotally mounted to a column fastened to the vehicle roof and tunnel. US 3,392,989 has the same feature.

25 US 3,713,694 teaches a pair of rotatable U-shaped shoulder-arms, connected to each other by an upper crank shaft transversely arranged in the upper portion of the seat backrest, and a lever arm, which, adjacent to the side of the seat cushion, is connected to a rotatable lower crank shaft, transversely arranged to the rear portion thereof and loosely connected to the upper crank, by a connector. When the lever arm is moved downwardly, the upper crank rotates the U-shaped shoulder-arms downwardly to restrain the shoulders of a passenger, sitting on the seat. DE-OS 2152146 has the same feature.

30 US 3,829,158 addresses a body-restraining device comprising a rotatable U-shaped hook, both ends, provided with a pair of pivots and arranged in the seat backrest. When rotating from a resting position, in which the U-shaped hook is located above the head, to an operative position the U-shaped hook envelopes the upper part of the body of a passenger sitting on the seat.

35 Ref. to US 4,700,632 a passenger, in a standing position on a roller coaster, is restrained by a device comprising a seat placed between his legs, a back member, into which a head rest is incorporated, and a pair of arms, one of which remains fixed and the other is movable, defines a harness for retaining the upper part of his body.

40 US 5,529,382 addresses an over-shoulder-rotatable operating device, permitting fine adjustments of two pairs of pivoting arms to a body proportion, for amusement attractions. The device comprises a lower plate, resting against the passenger's abdomen and the pairs of pivoting arms, the first pair located behind and above the passenger's shoulders and the second pair in conjunction with the lower plate in front of the passenger.

Ref. to EP 0003354 A1, equivalent to DE-OS 2803574, a seat backrest has a pair of recesses at the seat sides to house a pair of rotatable legs of a U-shaped seat member in a resting position. In an operative position the legs are rotated vertically, thus facilitating the U-shaped seat member to restrain a child, sitting on the seat.

5 According to the above-listed patent documents US 2,833,554, US 3,392,989, US 3,713,694, US 3,829,158, US 3,901,550 (DE-OS 24 28 285), US 4,700,632, US 5,529,382, DE-OS 2152146 and EP 0003354 A1 (DE-OS 2803574) a restraint device, substituted for a seat belt (restraint system), restrains the shoulders, lap and/or abdomen of a passenger. This feature is in contradiction to the law, valid world-wide, enforcing the use of seat belts during 10 travel. Unbelted passengers are not tolerated. Police fine them for belt violations. Recently, in Washington State a hefty \$ 86 fine per passenger, imposed therefor, is legislated. Furthermore, Administrations world-wide would reject motor vehicles, equipped with such restraint devices, thus putting the car manufacturer out of business. Moreover, all the restraint devices need space, the design is bulky and unattractive. By no 15 means can child-seats and/or baby cots be installed in the car. The overall stylish impression of the vehicle is not beneficial to sales. When cleaning, repairing or stepping in or out of the vehicle body, the passengers, in particular, children can stumble over such devices, unintentionally hit them and/or be obstructed, for example, by the seat harnesses, located in the resting position at the head level, ref. to US 3,392,989. Evidently, all the restraint devices 20 are incapable of absorbing great energy, dampening strong vibrations, ensuring the restraint of the passengers in any real-world accident, for example, submarining, rollover, multi-crash etc. As a result, passengers are exposed to the danger of being severely/fatally injured and/or burnt alive if the car catches fire.

According to US 3,901,550, that has the best feature among the above-mentioned restraint 25 devices, the passenger is secured by the restraint of both shoulders and the pelvis **96** by means of two pairs of air-cushioned guard arms **16** and **18**. The following problem cases cast doubt on the survival chance and applicability:

I. Due to the gap „ $s_i$ “ between the shoulders and shoulder cap the shoulders and head **95.1** can oscillate. High injury severity results from

30 1. large acceleration of head of a belted dummy about 83 g in the crash test of a vehicle without airbag [1],  
2. limited energy-absorption property of the air chambers to dissipate large energy of the upper part of body of belted dummy, thrown forward, by a force of about 64 g and  
3. lack of neck cap to dissipate large energy of the head, yaw-accelerated at the yaw angle **O** [2], acting as the second rotating mass.

35 A passenger, submarining (slipping downward) in a rear collision, releases himself from the restraint by the guard arms **16** and **18**, thus exposed to severe/fatal injury.

In a real-world accident, the load cases of which are illustrated in Figs. 1 and 2, the survival chance is low due to lack of energy- and shock absorber.

40 II. Upper part of body, defined by various outer contour from **SC1** to „**SC3**“, for example, upon putting a thick winter coat, can't be retained because only one outer contour „**SC2**“ is configured when pulling together the air chambers **26** of guard arms **16** via a tension strap **30**. The outer contour is determined by two body shapes (both shoulders and chest) and the passenger, whose circumference varies depending on the clothes worn.

45 III. The manufacturing costs for two pairs of guard arms and two feeding systems are higher than that of the shoulder- and neck holder including the seat belt.

IV. Passengers are severely/fatally injured in the event of submarining or rolling over.

According to DE 37 06 394 C1 a backrest of a front vehicle seat is equipped with deformation elements, which are deformed beyond the yield limit for the purpose of undampened energy-absorption when

5    – a passenger, seated in the front, is thrown against the seat backrest in a rear collision or  
– an unbelted passenger, seated in the back, is thrown against the seat backrest in a front collision.

The supporting members of the seat backrest frame serve as deformation elements, to which expanding and contracting elements are arranged, the geometry of which and elastic limit of which vary along the length of the seat backrest.

10   Ref. to DE 42 38 549 A1 thin walls of a seat backrest frame are proposed for undampened energy-absorption.

According to DE 92 02 219 U1 a belt retractor, equipped with a clamping device, acts as delimiter of a restraint system in conjunction with deformation and energy-absorption. The belt retractor and clamping device are connected to each other by a plate with ribs. Due to 15   clamping of the belt in excess of a threshold value the ribs are deformed, thus increasing the distance of the clamping device from the belt retractor. The energy, imposed on the belted passenger, is released by the fracture of predetermined sites of the ribs.

20   A seat ref. to EP 04234348 A1 is proposed for survival chance in a mid-front collision of car, train or aeroplane. A pair of energy absorbers is pivotally attached to a pair of front and rear seat legs, which are pivotally attached to the floor 6 and a seat-cushion frame. Each energy absorber consists of a rod, pivotally attached to the rear seat leg and floor 6 and having a cone-shaped end, and a tube, pivotally attached to the front seat leg and seat-cushion frame and having a cone-shaped collar to receive the end of the rod. During the movement of the seat in mid-front collision, the end of the rod expands (reams) the tube, thus performing 25   work of deformation and friction in order to dissipate energy. For the purpose of gliding the end of the rod along the inner cylinder of the tube, the wall may not be cracked, but only deformed.

30   Exemplified by DE 39 33 721 A1, another energy-absorbing friction device, mounted to a vehicle part, has a tube, which is deformed by the belt force. The end of a rod, protruding through the tube, is connected to the seat belt and several barrels of a role (bearing balls) are arranged around the other end, inserted in the inner cylinder of tube. The outer diameter of the rod and barrels of a role is a little larger than the inner diameter of tube. Under the load of belt force the barrels expand the inner cylinder of tube.

35   A very low work of deformation and friction is achieved, nevertheless, this invention contains the first-promising feature which only in co-operation with the seat belt is able to effectively absorb energy.

40   US 5,544,918 discloses an energy-absorbing management device, which comprises a crushable (deformable) honeycomb to absorb energy and a controller consisting of three-sensor mechanisms to monitor and sense the weight of the passenger, his forward motion and the severity of the vehicle collision. Unfortunately, sensors are incapable of evaluating crash data within few milliseconds and responsible for false deployment of airbags, resulting in decapitations, severe/fatal injuries and burns, which are reported in [6 to 8] and EP 0844939 B1 (US 09/125,455). Due to the unreliable operation of sensors car manufacturer has no choice to start recall program, which impairs the reputation and is costly.

45   A more reliable and far cheaper energy-absorbing device is described hereinafter and in DE 197 58 497 C2.

## SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to provide for a belted passenger a transport system a shoulder- and neck holder which resolves the above-mentioned shortcomings and deficiencies, dampen vibrations and decreases all the loads below the injury-relevant threshold values in the event of a real-world accident, shown in **Figs. 1 and 2**, or in an inflight turbulence.

A second object of the present invention resides in emergency operation by means of a common release button, when depressed, either to release all the all latch plates of the insertable shoulder- and neck holder from the respective buckle assemblies or to move a rotatable device of the rotatable shoulder- and neck holder back from the operative position to the resting position. By law passengers travelling in a motor vehicle or experiencing flight-turbulence must remain belted. The need for a belted mother to turn around becomes apparent, because she must attend to her belted children crying and sitting on the rear seat.

A third object of the present invention resides in one-click operation by means of a master release button, when depressed, to release the main latch plate and all the additional latch plates from the main and supplemental buckle assemblies, either to release all the all latch plates of the insertable shoulder- and neck holder from the respective buckle assemblies or to move the rotatable device of the rotatable shoulder- and neck holder back from the operative position to the resting position. In emergency cases paramedics and fire-fighters can easily rescue the injured passengers. Within seconds the passengers can step out of the transport system when catching fire.

A fourth object of the present invention resides in a cost-, space-saving integration of the a seat belt, the insertable shoulder- and neck holder, energy absorbers, sets of vibration-dampening energy absorbers, an anti-submarining seat-belt assembly and the seat into an energy-absorbing, vibration-dampening safety seat, which can be converted into a safety baby-cot **86**, safety child-seat **85a**, **85b** or safety adult-seat **85a to 85e** or vice-versa, illustrated in **Fig. 14**. As a result, the rate of seat occupancy in a bus, train or an aeroplane is increased and there is no need to purchase child-seats and baby-cots and transport them, when not used, back anymore.

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## INDUSTRIAL APPLICABILITY

It should be apparent that the invention provides a substantially improved restraint including the following features:

- 35 - In compliance with the law, valid world-wide, enforcing the use of seat belts by the use of the conventional or newest seat belt ref. to WO 99/24294, the restraint of shoulders and/or neck by the shoulder- and/or neck holder can be determined before the travel/flight or in accident/turbulence or in excess of a threshold speed e.g. over 80 km/h. The deflecting point or end of a conventional seat belt **3e** (**Fig. 14**) is located at the top edge of seat backrest. The compound of two restraint systems **1c / 10**, **1a / 10a**, **1b / 10b**, **1d / 10d**, **1e / 10e** minimizes movements/motions/torsions and all acceleration-dependant loads (**Fig. 1**), imposed on shoulders, neck, torso, the lower part of body and, in particular, head acting as the 2nd mass.
- 40 - The upper part **95** of body consists of torso **95.2** and head **95.1**. In the z-y and x-y plane (**Fig. 1**) the pitch- and yaw angle **U<sub>s</sub>** and **O** of the 1st mass of torso about the rotating „S”- and z-axes converge toward zero owing to the restraint of shoulders of the belted torso,
- 45

thus reducing the forward motion, pitch acceleration  $\ddot{U}_S$ ,  $\ddot{U}_H$ - and yaw acceleration  $\ddot{O}$ -dependent forces  $F_{Sy}$ ,  $F_{Hy}$  and  $T$  in arbitrary front collision. Analogously, the forces  $T$ ,  $F_{Sx}$ ,  $F_{Ix}$  and/or  $F_{Sz}$  are reduced in arbitrary side collision and/or rollover. This feature contributes to new development to increase the reliability of substitutes for airbags. Due to the unreliability and false deployment of airbags newspapers [3] have reported recall programs, decapitations, severe/fatal injuries, burns etc.

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- Beyond doubt, one-piece neck cap **10.4a**, **10.4c**, rigidly connected to shoulder cap **10.2a**, **10.2c**, sustains the neck e.g. of a cervical trauma suffering passenger at the best. If such shoulder- and neck holders **10a**, **10c** were installed in a vehicle or an aeroplane, healthy 10 passengers would reject to use them when it is hot or the passenger is wearing tie or jewellery around her/his neck. This controversy is resolved by the features of one the Claims 1 to 4 in association with Claim 13.
- By making the caps **10.2**, **10.2a** to **10.2f** and a number of the respective alternate energy absorbers **10.3**, **10.3a** even a passenger with broad shoulders can use the holder by changing shoulder caps.

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Moreover, the overall stylish impression of seats is spoilt by shoulder- and/or neck-shaped caps, when not in use, thus impairing the sales. Understandably, the design of caps of holders e.g. **10**, **10b** (Fig. 14) for expensive luxury cars depends, principally, on the form of the seat **3c**, **3b**. It is more likely that seats of expensive luxury cars are equipped with shoulder- and neck holders **10d**, **10e** (Figs. 1, 8), which are located in the seat backrests 20 when not used. To protect the broad shouldered passenger the shoulder caps must be changed. The decision for shoulder- or seat -shaped caps depends on the purpose of holders installed in the motor vehicle (bus, ambulance, van, luxury car etc.), train and aeroplane. This controversy is resolved by the features of one the Claims 16 to 20.

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- The problem case II, aforementioned, is resolved by variable restraint of a single body member comprising the shoulders and neck. Preferably, one- or two-piece, shoulder-shaped energy absorbers **10.3**, **10.3a** can be detached from one- or two-piece, deformable caps **10.2**, **10.2a** to **10.2f** and one- or two-piece, neck-shaped energy absorbers **10.5**, **10.5a**, **10.5c** from one- or two-piece, deformable caps **10.4**, **10.4a** to **10.4c**, **10.4f** as well 30 as fastened thereto via adhesive fastener such as zip-, snap-in- or Velcro fastener. The absorber as well as cap can be made of one- or two pieces.

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For the purpose of cost saving associated with the demand for passengers, with different neck- and shoulder shapes, a large number of neck- and shoulder-shaped energy absorbers **10.3**, **10.3a**, **10.5**, **10.5a**, **10.5c** and a low number of caps are produced. Fig. 14 exemplifies the adaptation of the holder to the body proportion of a child, sitting on the seat **3a**, **3b**, by using detachable holder **10a**, **10b**.

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- For the purpose of quick storage and removal, the holder **10a** to **10c** is inserted into the seat backrest or -cushion of seat **3a** to **3c** (Fig. 14), secured by inserting the pair of latch plates **10.1**, **10.1b**, **10.1f** therein and released by pressing the release button **87a** to **87c**. Both latch plates of shoulder- and neck holder **10a** are disengaged from seat cushion **3.1a** (Fig. 14) by pressing the release button **87a**. As front portion of that seat cushion the holder **10a** is removed from the cutaway portion (opening) to exploit its space for accommodation of both lower legs of a child sitting on the rear portion thereof.
- For the convenience of the passenger and in cases of quick-rescue and emergency a master release button **84** of lap buckle assembly **9.1** is pressed to release all latch plates of the seat belt from the respective buckle assemblies and

- \* to move the holder **10d, 10e** back from the operative position to the resting position or
- \* to release all latch plates of holder **10, 10a to 10c, 10f** from the respective buckle assemblies.

5    – Both casings **29a** of rotatable device **28a** are guided by two pairs of inner tubes **71, 72** of seat backrest frame **3.4d, 3.4e** and can be locked in the required height.

10   – Large impact energy is absorbed, during which vibration is damped, by

- \* fracture of pads of predetermined fracture „**S<sub>11</sub>**“ to „**S<sub>nn</sub>**“ and „**H<sub>11</sub>**“ to „**H<sub>nm</sub>**“, which define the energy absorber **10.3, 10.3a** and **10.5, 10.5a, 10.5c**;
- \* fracture of sites of predetermined fracture „**s**“ of spring **10.9**;
- \* fracture of sites of predetermined fracture of clamping elements of the following sets of energy absorbers **30, 40, 50** (Figs. 10 to 12) having control-wires **37, 47, 57**, representing **40e, 40f** having wires **47e, 47f**, which are tautly, less tautly and/or loosely connected to holder **10e**; and
- \* friction of clamping elements **32.1 to 32.e, 42.1 to 42.e, 52.1 to 52.e**, which move along the respective retaining elements **31, 41, 51**.

15   – The shoulder- and/or neck cap can be inserted or rotatably attached to or in the seat backrest. Furthermore, it can be adapted to the body proportion of a passenger by a width- and height-adjustable mechanism of the holder.

20   The sets of energy absorbers and accommodation thereof in the frame of seat backrest and/or seat cushion account for a method of construction to save space, weight and costs and to increase stiffness. Furthermore, the energy-absorbing elements are made by extrusion, depth extrusion, casting, die casting or of spring plate or of spring steel. A preference for the embodiments is given to elements, having round profile, which are the cheapest and easiest to manufacture.

25   The costs and reject rate are lowered by a single tolerance (over- or undermeasure of a round profile), pre-tensioning (biasing) the clamping elements on or in the retaining element and pre-assembling all sets of energy absorbers, which are pre-loaded, for the delivery and final assembly to the frame of seat backrest and/or seat cushion.

30   The position of clamping elements e.g. **42, 42.1, ..., 42.n** to each other can be adjusted by choosing the adjusting holes „**L<sub>1</sub>**“ to „**L<sub>e</sub>**“ and/or by clamping the brackets **37b1** on the wires.

35   Owing to the property of the great energy-absorption by small mass, lighter materials such as magnesium-, aluminium-extrusion, die casting of GD-MgA12 or alloys or carbon/glass fibre-reinforced plastics, used for skis, are recommended for the caps of the holder, latch plates and parts of the set of energy absorbers.

40   – Fracture of sites of predetermined fracture „**s**“ can be used as court-evidence for a passenger having belted in the accident.

45   – Retaining elements (Figs. 1, 10, 11), integrated into the frame of seat backrest and/or seat cushion, enormously increase the stiffness of seat. The buckle assemblies, receiving the latch plates, are sustained by the frame of seat backrest and/or seat cushion.

Advantageously, retaining elements such as **31c** can be exploited as the seat legs of the seat **3c** (Fig. 14).

– Two- or three-point seat belt can be equipped with sets of energy absorbers. The guide pieces of buckle assemblies, plug-in connected to the respective latch plates, have two functions to integrate energy absorbers into the two-, three- or multi-point seat belt and to guide the movement of the buckle assemblies, when loaded or unloaded.

- Due to the increased tension on the wire the clamping element performs the work of deformation and friction, which is released in excess of threshold value resulting in fracture of sites of predetermined fracture „s”, two sites shown in **Fig. 11**, upon the contact with both heads of stop pin or bolt **46.1, ..., 46.n**. The site of predetermined fracture can be formed as crack, corrugation, hole or recess.
- In another embodiment the performed work (energy) is released by fracture
  - \* in excess of the yield limit of the clamping element,
  - \* due to constrained deformation of carrier piece or expanding (reaming) the clamping element upon the contact with a wedge-shaped stop element **41.3** (**Fig. 11**) or with a wedge-shaped rib **41.1, 51.1** (**Fig. 12**).
- Generally, the energy absorber consists of a tube-shaped base body with/without rib, serving as retaining element, and at least one clamping element, which is arranged to or in the retaining element. Wires are employed to tautly, less tautly and/or loosely connect
  - \* clamping elements to each other, whereby a row of energy absorbers e.g. **R42** (not denoted) is defined from the expanding clamping elements **42, 42.1 to 42.n** and the retaining element **41** (**Fig. 11**). In similar manner the other rows of energy absorbers such as **R32, R52** etc. can be built together;
  - \* rows of energy absorbers to define a set of energy absorbers **30, 40, 50** (**Figs. 10 to 12**) and
  - \* sets of energy absorbers to couple member **1.2a, 1.2b** of tie band (catch band) **1.1a, 1.1b, 1.5, 1.6, 47e, 47f** (**Figs. 1, 13a to 13c**) to dissipate subenergies „ $\Delta F_i$ ” by applying the energy-absorbing method.

Injury-irrelevant threshold value is defined by the difference between two forces „ $\Delta F_1$ ”, lower than the injury-related load. The threshold values may have different magnitudes.

For the energy-absorption up to the starting threshold value „ $\Delta F_1$ ”, at least one clamping element **42e, 42f** (**Fig. 1**) or energy absorber **10.3, 10.3a, 10.5, 10.5a, 10.5c** is responsible. In order to prevent vibration and to fix the onset of energy-absorption at least one control-clamping element **52** must be biased up to an onset force-level e.g. „ $\Delta F_1 - 500 \text{ N}$ ”, which is lower than „ $\Delta F_1$ ”. Over this onset force-level the element, pulled by the corresponding wire **57**, performs work of deformation and friction, during which the energy „ $\Delta F_1$ ” is released by fracture of sites of predetermined fracture of clamping element **42e, 42f**, so that the passenger is neither injured nor thrown back. The energy increase about „ $\Delta F_2$ ” is compensated by the fracture of at least one complementary clamping element **52.1 to 52.n**, so that the passenger is neither injured nor thrown back.

The gradual reduction of energy is repeated so long up to a load zone defined of „ $\Delta F_e - 500 \text{ N}$ ”, in which all clamping elements are broken, the control-clamping elements **52** cannot move anymore and at least one control-clamping element **42**, biased at „ $\Delta F_f - 500 \text{ N}$ ”, and/or at least one clamping element of set of energy absorbers **40** perform(s) work of deformation and friction.

The energy increase about „ $\Delta F_f$ ” is compensated by the fracture of the control-clamping elements **52** and/or of at least one complementary clamping element **42.1 to 42.n**, so that the passenger is neither injured nor thrown back. The gradual reduction of energy is repeated so long till

1. the total energy „ $F_n$ “ is consumed or
2. a new load zone defined of e.g. „ $\Delta F_h - 500 \text{ N}$ “, in which all clamping elements are broken, the control-clamping elements **42** can't move anymore and at least one of the following sets of energy absorbers decrease energy, such as

5      \* **30, 40a, 50a** (not shown) of the other structural half of seat-cushion frame **3.3a**,

      \* **40, 50** of the other structural half of seat backrest frame **3.4a**,

      \* **30M, 40M, 50M, 65M** (not shown) fastened to the cross members **3.41, 3.42** of seat backrest frame **3.4a** facing each other,

      \* **30N, 40N, 50N, 65N** (not shown) fastened to the cross members **3.31, 3.33** (not shown) of seat-cushion frame **3.3a** facing each other.

10     Because the passenger was subjected to a succession of injury-irrelevant threshold values „ $\Delta F_i$ “, where  $i = 1$  to  $n$ , during the accident and restrained by the seat belt, tensile strength of which about 24,000 N is substantially higher than „ $\Delta F_i$ “, he needs only to depress the master release button **84**, detaching all latch plates from buckle assemblies, and egresses, unscathed, from the vehicle, train or aeroplane (**Figs. 1 and 14**).

15     An energy-absorbing device, comprising a number of sets of energy absorbers, having different threshold values, is connected to the holder and to the latch plates of the seat belt in plug-in connection with the buckle assemblies of the seat backrest and/or -cushion.

- In another embodiment a sound-proofing material **83**, having arbitrary friction coefficient  $\mu_0$ , different or progressive friction coefficient, is attached to the contact surface of retaining element and/or clamping element for the purpose of dampening vibration and performing work of friction. Furthermore, it is possible to coat the retaining elements and corresponding clamping elements, thus eliminating any noise.
- In the event of submerging and/or rollover the energy is dissipated by sets of energy absorbers, which are arranged in the seat-cushion frame and are tautly, less tautly and/or loosely connected to the buckle assembly.
- A single seat can be equipped with holder for persons (adults and/or children) of different ages related to weight groups, which depend on the appropriate sets of energy absorbers. The sets of energy absorbers and/or energy absorbers have different threshold values.

20     Owing to these features the survival chance of the passengers is enhanced and the seats, equipped therewith, can be modified to be used by adults or children, thus increasing the rate of seat occupancy in a train, bus or an aeroplane, exemplified in **Fig. 14**.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

A number of embodiments, other advantages and features of the present invention will be described in the accompanying tables and drawings with reference to the xyz global coordinate system:

40     **Fig. 1** is a side view a 7th embodiment of a rotatable shoulder holder **10e**, equipped with energy absorbers **10.3, 40e** and **40f**, rotated by a 2nd embodiment of a rotatable device **28a** from a resting position **P** to an operative position **P<sub>1</sub>**.

**Fig. 2** is a perspective view of a restrained dummy, thrown forward in an offset crash test [1].

**Fig. 3** is a perspective view of a 1st embodiment of a half of an insertable shoulder- and neck holder **10** equipped with a set of energy absorbers **10.3, 10.5** and latch plate **10.1**.

45     **Fig. 4** is a schematic, perspective view of a 2nd embodiment of an insertable shoulder- and neck holder **10a** equipped with a wider chin-supporting neck collar **10.4a**, energy absorbers **10.3a, 10.5a** and latch plates **10.1f**.

**Fig. 5** is a schematic view of a 3rd embodiment of a half of an insertable shoulder- and neck holder **10b** equipped with the energy absorbers **10.3, 10.5, 10.9**.

**Fig. 6** is a schematic view of a 4th embodiment of an insertable shoulder- and neck holder **10c** equipped with energy absorbers.

5 **Fig. 7** is a schematic view of a 5th embodiment of a half of an insertable shoulder- and neck holder **10f**, equipped with a latch plate **10.1f** in plug-in connection with a buckle assembly **4b**.

10 **Fig. 8** is a perspective view of a 6th embodiment of a half of a rotatable shoulder holder **10d**, rotated by a 1st embodiment of a rotatable device **28** from a resting position P to an operative position **P<sub>1</sub>**.

**Fig. 9** illustrates a total load „F<sub>n</sub>”, absorbed by the restraint system in co-operation with an energy-absorbing, vibration-dampening device, in the event of a real-world accident.

15 **Fig. 10** is a schematic, perspective view of a 1st embodiment of a set of energy absorbers **30, 40e, 40f**.

**Fig. 11** is a schematic, perspective view of a 2nd embodiment of a set of energy absorbers **40, 40e, 40f**.

20 **Fig. 11a** is a partially enlarged perspective view of a clamping element with sites of predetermined fracture „s” and both heads of a stop pin to block the clamping element.

**Fig. 12** is a schematic, perspective view of a 3rd embodiment of a set of energy absorbers **50, 40e, 40f**.

25 **Fig. 13a** is a schematic, perspective view of a 1st embodiment of a buckle assembly **4a** comprising a guide piece **4.7a**, release cable **4.2**, tie band **1.1a** and coupling member **1.2a**.

**Fig. 13b** is a schematic, perspective view of a 2nd embodiment of a buckle assembly **4b** comprising a guide piece **4.7b**, an electrical motor **4.2b**, a tie band **1.1b** and coupling member **1.2b**.

30 **Fig. 13c** is a cross-sectional view of a 3rd embodiment of a buckle assembly **4c** comprising two tie bands **1.5, 1.6** along the line II-II of **Fig. 13d**.

**Fig. 13d** is a cross-sectional view of buckle assembly **4.8c**, adjustable along the width of the back rest, having two holes to loosely guide two tie bands **1.5, 1.6**.

35 **Fig. 14** is a front view of safety seats **85a to 85e, 86**, into which the seat belts **1a to 1e**, sets of energy absorbers, shoulder holders **10, 10a, 10b, 10d, 10e** and seats **3a to 3e** are integrated, for passengers with different weights and body proportions.

### 35 DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The advantages of the preferred embodiments, above-mentioned in the Chap. "Summary of the advantages...", are outlined hereinafter with regard to the functions and features thereof.

40 The method of the present invention in co-operation with a seat belt capitalizes on the premise that the total energy (magnitude of energy) is subdivided (**Fig. 9**), at the best, into a number of subenergies which are released in excess of the respective injury-irrelevant values, pursuant to the energy-absorbing method, above-mentioned. This will be apparent by formulating all forces (**Fig. 1**), imposed on the torso **95.2** and head **95.1** of the passenger, in the event of a real-world accident where the torso, both shoulders and neck of a passenger are restrained by the shoulder- and neck holder and three-point or multi-point seat belt and the energy of two masses of the torso and head are absorbed by the energy-absorbers thereof.

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The features are applicable for any motor vehicle, provided with arbitrary post sections (pillars), train or aeroplane.

In the 1st to 7th embodiment the shoulder- and/or neck holder **10, 10a to 10f**, shown in **Figs. 1, 3 to 8**, comprises

5 – one- or two-piece caps **10.2, 10.2a to 10.2f** with the shoulder-shaped energy absorbers **10.3, 10.3a** and/or  
– one- or two-piece caps **10.4, 10.4a to 10.4c, 10.4f** with the neck-shaped energy absorber **10.5, 10.5a, 10.5c**.

10 Two-piece caps of the shoulder holder have an advantage over a one-piece cap of the shoulder holder that it can be put into use for a passenger with two different shoulders. The problem of the one-piece cap of the shoulder holder can only be resolved by the use of two different shoulder energy absorbers.

15 The cap of shoulder- and neck holder **10, 10b** (**Figs. 3 and 5**) is built by inserting a pair of neck-caps **10.4, 10.4b** into a pair of shoulder-caps **10.2, 10.2b**. This feature makes the design of the neck caps, insertably attachable thereto as well as detachable therefrom, possible.

20 Thanks to such design the passenger can decide for the use of the neck caps. If he or she is born with a weak neck muscle, the pair of neck-caps must be insertably attached thereto. On a hot day the neck caps can be removed therefrom. However, for children and persons, having very weak neck muscle, in particular when suffering from cervical trauma, the neck-shaped cap **10.4a** of holder **10a** is recommended. Its wider chin-supporting energy absorber **10.5a** (**Fig. 4**) improves the properties of bracing the head and substantially absorbing energy during the forward motion of the passenger.

25 To restrain the shoulders and neck of a passenger, the one-piece holder **10a**, in closed form and using a connecting cap **10.11**, has the greatest stiffness, however by removing that connecting cap the holder **10c** in open form does not block out air flow. This controversy is resolved by the stiff rotatable device **28, 28a** of rotatable holder **10d, 10e** in the different embodiments.

30 The latch plate **10.1** is pivotally attached to the flange **10.12** of shoulder- and neck holder **10** by pin **10.6** or by bolt **10.6a** and nut **10.6b**. The adjustment to the shoulder shape is done by rotating the bolt **10.7** in threaded hole of flange **10.12**. Finally, that bolt is secured by nut **10.8**. Time is greatly consumed for the removal of the belt from the closed apertures of cap **10.2** and the latch plate **10.1**, to loosely guide the belt portion **1.1**, in order to store the holder. Thanks to the open aperture **10.14** of cap **10.2b, 10.2c, 10.2f** and open aperture of latch plate **10.1b**, the belt, when strapped over the holder, can be loosely locked, guided by quick-release pin **10.10** and released by withdrawal of quick-release pin.

35 In the 5th embodiment ref. to **Fig. 7** the latch plate **10.1f** is secured to the flange **10.12f** by pin **10.6**, bolt **10.6a** and nut **10.6b**. By rotation of bolt **10.6a** in the threaded hole of flange **10.12f**, the cap **10.2f** can be moved along the width of the seat backrest.

40 In the 1st or 2nd embodiment ref. to **Figs. 1 and 8** each of the pair of casings **29, 29a**, form-locking connected to each other, of rotatable device **28, 28a** of holder **10d, 10e** consists of two outer tubes

45 – **28.1, 28.2**, force-locking connected with the coupling wall **28.3**, and an L-shaped plate **28.4**, or  
– **41e, 41f**, force-locking connected with the coupling wall **28.3**, and an L-shaped, partly laterally closed and partly laterally open plate **28.4a**.

The end of each rotatable lever 28.5, 28.5a is loosely guided between plate 28.4, 28.4a and coupling wall 28.3. The first ends of both rotatable levers are connected to each other by shaft 28.7. The cap 10.2d, 10.2e and release cam 28.6, 28.6a are fastened to the second end of each rotatable lever. In resting position each cap is located in the seat backrest or on its

5 upper portion, if necessary, underneath the head rest 3.6a. If a supporting tube 3.61 is available, the cap, recessed about that supporting tube, must be reinforced by reinforcing plate 10.13.

Because the outer tubes 28.1, 28.2 or 41e, 41f are guided by inner tubes 71, 72 of seat 10 backrest frame 3.4d, 3.4e, the height of the casings is adjusted in the direction of arrow „U“ (Figs. 1, 8) by manual operation or by a drive apparatus 80 e.g. hydraulic-piston cylinder unit, electrical motor (not drawn), similar to 4.2b shown in Fig. 13b.

The drive apparatus 80 can be activated by a switch, release button, controller, sensor or an accelerator pedal in reference to one of the Claims 7 to 10. Upon e.g. tipping the switch or release button the drive apparatus moves the holder 10d, 10e back to the resting position.

15 For the convenience of the passenger stepping out of the vehicle or in cases of emergency all latch plates of the seat belt are disengaged and the drive apparatus moves the holder 10d, 10e back to the resting position when depressing the master release button 84 of lap buckle assembly 9.1 (Fig. 14).

Due to the rotation of both rotatable levers 28.5, 28.5a, operated manually or by drive 20 apparatus 80, both release cams 28.6, 28.6a force the rotation of the lock pawls 28.8, 28.8a, pre-loaded (biased) by first springs 28.10, 28.10a, thereby permitting the locking pins 28.12, pre-loaded by second springs 28.13, and loosely guided in guide tubes 28.11, to move into the holes 28.14 and block the rotatable levers

- 28.5 in both directions or
- 28.5a in one direction.

25 When blocked, the loads in the event of rollover, yawing and/or turbulence-related vibration are reduced by the deformable holder 10d, 10e equipped with energy absorbers 10.3. The position of each guide tube 28.11 at the coupling wall 28.3 is denoted by the hole 28.14.

From the operative position P<sub>1</sub> to the resting position P both rotatable levers 28.5, 28.5a snap 30 into the stop pieces 28.9, 28.9a and are retained thereby.

The belt portion 1.1, 1.2 is loosely guided by U-shaped plate 10.15, similar to 10.14, of cap 10.2e and, if necessary, loosely locked by quick-release pin 10.10 (Fig. 5).

In another energy-absorbing embodiment, the long outer tubes 41e, 41f, serving as retaining 35 elements and girders, are parts of seat backrest frame 3.4d, 3.4e and energy absorbers 40e, 40f having clamping elements 42e, 42f, which are tightly, less tightly and/or loosely connected to the pair of rotatable levers 28.5a via the stop pieces 28.9a, serving as deflectors, by wires 47e, 47f in order to determine the onset of energy-absorption. Due to the forward motion of the dotted-line torso 95.2 and head 95.1 each dotted-line rotatable lever 28.5a with cap 10.2e is rotated to the position P<sub>2</sub> through the opening of L-shaped, partly laterally-closed 40 and partly laterally-open plate 28.4a, during which the work of deformation and friction is achieved by the deflection of the dotted-line clamping elements 42e, 42f along the respective retaining elements 41e, 41f. The stored energy is released in excess of the yield strength and/or of the threshold values. Additional clamping elements 32, 32.1 to 32.n, 42, 42.1 to 45 42.n, 52, 52.1 to 52.n can be arbitrarily arranged or be series-connected to clamping element 42e, 42f to absorb great energy and dampen strong vibrations.

In the 1st embodiment the set of vibration-dampening energy absorbers **30, 40e, 40f** (Fig. 10) comprises a retaining element **31**, control-wire **37**, control-clamping element **32** and complementary clamping elements **32.1 to 32.n** (not drawn). After projecting through or into the cylinder-shaped edges **37c1** of control-clamping element **32**, both end portions of complementary wire **37a1** of control-wire **37** are secured by clamping two brackets **37b1** or both cylinder-shaped ends **37c1** therewith. The inner diameter „ $d_i$ “ of retaining element **31, 41** is a little larger than the outer diameter „ $d_i$ “ of inner tubes **71, 72**.

In the 2nd embodiment ref. to Figs. 11, 11a the set of vibration-dampening energy absorbers **40, 40e, 40f** comprises a retaining element **41**, control-wire **47**, control-clamping element **42** and complementary clamping elements **42.1 to 42.n**. Owing to taut, less taut and/or loose connection of complementary wires **47.1, ..., 47.n** with the clamping elements **42, 42.1, ..., 42.n**, if necessary by occupying another pair of adjusting holes „ $L_1$  to  $L_c$ “, the onset of each clamping element, biased, is determinable. Owing to arbitrary connection of wires with arbitrary clamping elements the fracture of the clamping elements can be predetermined in an arbitrary succession. Determinable, too, is the fracture of each clamping element to absorb energy, e.g. by reaming (bulging) the complementary clamping element **42.1, ..., 42.n** in contact with both heads of stop pin or bolt **46.1, ..., 46.n** with both sides of wedge-shaped stop element **41.3** or by fracture in excess of the yield strength when increasingly loaded.

In the 3rd embodiment ref. to Fig. 12 the set of vibration-dampening energy absorbers **50, 40e, 40f** comprises a cone-shaped retaining element **51**, control-wire **57**, control-clamping element **52** and clamping elements **52.1, .., 52.n** and **53.1, .., 53.n** (not-shown). Both ends of complementary wire **57a1** of control-wire **57** are secured to a control-clamping element **52** by rivets **57b1**.  
The load-deflection area is achieved progressively or arbitrarily by the expansion of cone-shaped clamping element **52, .., 52.n, 53, ..., 53.n** along

- the cone-shaped retaining element **51** and/or
- the longitudinal rib **51.1** whose thickness longitudinally increases.

The space in the seat backrest and -cushion is exploited to accommodate a number of sets of energy absorbers, having different threshold values for baby, child, adult, old woman and man, which are connected to the shoulder- and/or neck holder and buckle assemblies, whereto the latch plates of, preferably, the multi-point, one-piece seat belt of the seat **3a** to **3d**, shown in Fig. 14, are plug-in connected. In a real-world accident this energy-absorbing, vibration-dampening device, operating without sensors, but with the multi-point, one-piece seat belt gradually absorbs great energy below the injury-related values and dampens vibrations. In comparison with the energy-absorbing management device, monitored by the three-sensor mechanisms, aforementioned and proposed by US 5,544,918, the operation is more reliable, the injury severity is substantially lower, the manufacturing costs are far lower and there is neither recall programs nor court-cases.

In the 1st and 2nd embodiment of the buckle assembly **4a, 4b** (Figs. 13a and 13b), to receive latch plate **2, 11, 25**, the one-piece guide piece **4.7a, 4.7b** is provided with a recess **4.5a** or longitudinal groove **4.5b** to loosely guide tie band **1.1a, 1.1b**, having coupling member **1.2a, 1.2b**, to which the wires of sets of energy absorbers **30, 40, 50** are tautly, less tautly and/or loosely connected.

After the insertion, in the direction of double arrow, of a pair of engaging parts **4.10a**, **4.10b** of guide piece **4.7a**, **4.7b** in the apertures of the housing **4.8a**, **4.8b** of buckle assembly **4a**, **4b** the clamping parts **4.12** snap into the clamping holes **4.13**.

When the latch plate is pulled under the load of „ $\Delta F_1$  - 500 N”, less than the starting threshold value „ $\Delta F_1$ ”, the buckle assembly, clamping element/s and energy absorber/s move about the deflection „ $T_F$ ” (not drawn). In the state of non-deformation the housing **4.8a**, **4.8b** with/without clamping parts **4.12** must be pulled back into the engaging parts **4.10a**, **4.10b**. This is possible, when „ $T_L$ ” is at least as long as „ $T_s + T_F$ ”. Experiment can clarify, whether the clamping parts and clamping holes are needed. However, the clamping assemblies have the advantage of exactly positioning the buckle assembly in the seat backrest or -cushion.

Due to the restriction for the depth „ $T$ ” of seat backrest or -cushion (Fig. 14) the length „ $T_L$ ” of engaging parts **4.10a**, **4.10b** is restricted too, hence, the following countermeasures are required:

- When the buckle assembly under load of great impact energy moves along the engaging parts, the tie band **1.1a**, **1.1b** must be guided by the guide piece **4.7a**, **4.7b**, fastened to the seat frame;
- In order to exploit the depth „ $T$ ”, the length „ $T_z$ ” of latch plate and/or the length „ $T_L$ ” of engaging parts **4.10a**, **4.10b** is/are increased;
- By not using guide piece the wires of sets of energy absorbers can tautly, less tautly and/or loosely be connected to couple member **1.2a**, **1.2b** or an end of the seat belt; and/or
- Owing to biasing at least one control-clamping element **32**, **42**, **52** at „ $\Delta F_1$  - 500 N” the housing can only move in excess thereof for the purpose of undampened energy-absorption.

In the 3rd embodiment of the buckle assembly **4c** (Fig. 13c), to receive latch plate **2**, **9**, **11**, **25**, the housing **4.8c**, that can be moved along a pair of tube **27.3** of the frame of seat backrest or seat cushion and latched thereon, are provided with two holes **4.5c** to loosely guide tie bands **1.5**, **1.6**, having couple members **1.2a**, **1.2b**. A wire is projected through the hole **2.3** of buckle assembly **4c**. Both end portions, serving as tie bands **1.5**, **1.6**, are secured by a mutual bracket **1.7**. The engaging part **4.10c** of buckle assembly **4c** is in pig-tail- or form-locking connection to an aperture of housing **4.8c**. Large height- and width-adjustment can result in slackness and inaccuracy when biasing the wires. Such shortcoming is resolved by directly attaching the sets of energy absorbers to the parts (not drawn) of the height- and width-adjustable mechanism.

The buckle assemblies **4a**, **4b**, **4c**, having the release cable **4.2**, the electrical motor **4.2b** with a shaft **4.3b** and release cable **4.3**, are suited for buckle assemblies **4**, **7**, **8**, **8a**, **9.1**, **18a** / **19a** to **18n** / **19n** of the seats **3a** to **3c** (Fig. 14). When the release cables **4.2** or **4.3** of the buckle assemblies are connected to the master release button **84** of lap buckle assembly **9.1** (Fig. 14) the depressing the master release button **84** results in disengaging of all latch plates of the seat belt and holder **10**, **10a** to **10c**, **10f** therefrom. This one-click operation increases the convenience of the passenger, when stepping out as well as facilitates the quick-rescue of the injured passenger in accidents.

Thanks to plug-in connection of at least one anti-submarining latch plate **11**, **25**, movable along the lap belt portion **1.3**, with an anti-submarining buckle assembly **7**, **8**, **8a** of the seat cushion (Fig. 14), provided with sets of energy absorbers, the energy, imposed on both thighs, in the event of submaring and/or rollover is absorbed and released by fracture of the sites of predetermined fracture. To properly restrain both thighs of a child, sitting on the seat **3a**, three movable anti-submarining latch plates **11**, **25** are in plug-in connection with the

respective anti-submarining buckle assemblies 7, 8a. So a safety child-seat 85a, 85b is created by integration the seat belt, energy absorbers and holder into the seat itself.

Another application results from direct conversion of a child-seat 85a into

- a baby-cot 86 by flipping the seat backrest 3.2a into a baby-resting position or
- a safety adult-seat 85a by disconnecting the movable latch plates 25 from the anti-submarining buckle assemblies 8a, repositioning the seat backrest to an adult-seating position and mounting the holder 10a back into the cutaway of the seat cushion.

Thanks to the multi-purpose of energy-absorbing, vibration-dampening safety seat a high rate of seat occupancy in an aeroplane can be achieved and there is no need for purchasing child-seats and baby-cots, administrating, storing and transporting them anymore.

For safety reasons and easy access the latch plates 25, when not being used, are stored in a storage box 25.2 (Fig. 14). The belt-detachable latch plates 25, each having a quick-release pin 25.1 (similar to 10.10 shown in Fig. 5), are attached to any belt portion 1.1, 1.2, 1.3 when needed (Fig. 14).

Notably, any passenger of any age, body proportion and weight is protected from severe/fatal injury by the energy-absorbing device incorporated with the multi-point seat belt and insertable or rotatable attachment of the shoulder- and/or neck holder 10, 10a to 10f to the seat backrest frame.

Lack of functional tests to determine the permeability, stiffness and design of the caps and properties of energy-absorption it is necessary to design a number of holders to restrain the upper part of body 95 of a passenger (dummy), restrained, preferably, by the multi-point seat belt, in order to determine the cheapest design characterized by the best mode to reduce all acceleration-dependant forces, dampen vibrations and avoid whiplash in crash tests.

Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended claims, the present invention may be practised otherwise than as specifically described and illustrated.

What is claimed:

1. A restraint system equipped with a shoulder holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence, comprising

5 a seat belt (1d, 1e), consisting of several belt portions, at least one latch plate, a buckle assembly, a belt pretensioner and belt fittings;

a shoulder holder (10d), having a pair of shoulder caps (10.2d), which, when in a resting position, are located in a seat backrest (3.2d, 3.2e); and

10 a manually-operated rotatable device (28), having a pair of rotatable levers (28.5), retained by stop pieces (28.9) in the resting position, where the rotatable levers (28.5), having first ends, connected to the pair of shoulder caps (10.2d), and second ends, connected to each other by a shaft (28.7), are rotatably attached to a pair of casings (29), each of which, defined by an L-shaped plate (28.4) and two outer tubes (28.1, 28.2), connected to each other by a coupling wall (28.3), is height-adjustable, latchable and guided by inner tubes (71, 72) of a seat backrest frame (3.4d, 3.4e);

15 wherein

a passenger is restrained by the seat belt (1d, 1e) and his shoulders are restrained by the shoulder caps (10.2d), moved by the rotatable device, manually-operated, from the resting position to an operative position;

20 where at least one shoulder belt portion of the seat belt (1d, 1e) is extended over the respective shoulder cap and a U-shaped plate (10.15) thereof, when the rotatable levers (28.5) are manually rotated, causing release cams (28.6) of the rotatable levers to force a rotation of lock pawls (28.8), pre-loaded by first springs (28.10), thereby permitting locking pins (28.12), pre-loaded by second springs (28.13) and loosely guided in guide tubes (28.11), to move into holes (28.14) of the casings (29) and block the rotatable levers in both directions.

2. A restraint system equipped with a shoulder holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence, comprising

30 a seat belt (1, 1e), consisting of several belt portions, at least one latch plate, a buckle assembly, a belt pretensioner and belt fittings;

a shoulder holder (10e), having a pair of shoulder caps (10.2e), which, when in a resting position, are located on an upper portion of a seat backrest (3.2d, 3.2e); and

35 a motor-driven rotatable device (28a), having a drive apparatus (80) and a pair of rotatable levers (28.5a), having first ends, connected to the pair of shoulder caps (10.2e), and second ends, connected to each other by a shaft (28.7), are rotatably attached to a pair of casings (29a), each of which, defined by an L-shaped, partly laterally closed and partly laterally open plate (28.4a) and two outer tubes (41e, 41f), connected to each other by a coupling wall (28.3), is height adjustable, latchable and guided by inner tubes (71, 72) of a seat backrest frame (3.4d, 3.4e); and

40 vibration-dampening energy absorbers (40e, 40f), having a number of clamping elements (42e, 42f) provided with sites of predetermined fracture (s), biased, arranged along the outer tubes (41e, 41f) and tautly, less tautly and/or loosely connected to the pair of rotatable levers via stop pieces (28.9a) by corresponding wires (47e, 47f);

wherein

a passenger is restrained by the seat belt (1, 1e) and his shoulders are restrained by the shoulder caps (10.2e), moved by the rotatable device, driven by the drive apparatus (80), from the resting position to an operative position;

5 where at least one shoulder belt portion of the seat belt (1, 1e) is extended over the respective shoulder cap and a U-shaped plate (10.15) thereof, when the rotatable levers (28.5a) are rotated by the drive apparatus (80), causing release cams (28.6a) of the rotatable levers to force a rotation of lock pawls (28.8a), pre-loaded by first springs (28.10a), thereby permitting locking pins (28.12), pre-loaded by second springs (28.13) and loosely guided in guide tubes (28.11), to move into holes (28.14) of the casings (29a) and block the rotatable levers in one direction;

10 where in the real-world accident or in the inflight turbulence a forward motion of the torso and head rotates the rotatable levers in another direction through the openings of the L-shaped, partly laterally closed and partly laterally plates (28.4a), thus moving the clamping elements (42e, 42f) along the corresponding tubes (41e, 41f) resulting in a work of deformation and friction, during which vibrations are damped and a stored energy is released by fracture of the sites of predetermined fracture of the clamping elements in excess of respective threshold values.

15 3. A restraint system equipped with a shoulder holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence, comprising a seat belt (1, 1b, 1e), consisting of several belt portions, at least one latch plate, a buckle assembly, a belt pretensioner and belt fittings; a shoulder holder (10, 10b, 10f), having a pair of shoulder caps (10.2, 10.2b, 10.2f) with open apertures to receive the belt portions; 20 a pair of latch plates (10.1b), connected to the shoulder caps (10.2, 10.2b, 10.2f), with open apertures, in which the belt portions are loosely secured by quick-release pins (10.10), when the shoulder holder and the seat belt are fitted together, and released by withdrawal thereof for removal, when the shoulder holder is withdrawn; and 25 at least one pair of buckle assemblies (18a / 19a to 18n / 19n), attached in a seat backrest (3.2a, 3.2c); 30 wherein

a passenger is restrained by the seat belt (1, 1b, 1e) and his shoulders are restrained by the shoulder caps (10.2, 10.2b, 10.2f) upon plug-in connection of the latch plates (10.1b) with the buckle assemblies (18a / 19a to 18n / 19n); and

35 40 at least one shoulder belt portion of the seat belt (1, 1b, 1e) is extended over the open aperture of the corresponding shoulder cap and loosely secured in the open aperture of the latch plate.

4. A restraint system equipped with a shoulder- and neck holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence, comprising

a seat belt (1a, 1c, 1e), consisting of several belt portions, at least one latch plate, a buckle assembly, a belt pretensioner and belt fittings;

a one-piece shoulder- and neck holder (10a, 10c), defined by a neck cap (10.4a, 10.4c) and a shoulder cap (10.2a, 10.2c) with open apertures to receive the belt portions;

5 a pair of latch plates (10.1b), connected to the shoulder cap (10.2a, 10.2c), with open apertures, in which the belt portions are loosely secured by quick-release pins (10.10), when the one-piece shoulder- and neck holder and the seat belt are fitted together, and released by withdrawal thereof for removal, when the one-piece shoulder- and neck holder is withdrawn; and

10 at least one pair of buckle assemblies (18a / 19a to 18n / 19n), attached in a seat backrest (3.2a, 3.2c);

wherein

10 a passenger is restrained by the seat belt (1a, 1c, 1e) and his shoulders and his neck are restrained by the shoulder cap (10.2a, 10.2c) and neck cap (10.4a, 10.4c) upon plug-in connection of the latch plates (10.1b) with the buckle assemblies (18a / 19a to 18n / 19n); and

15 at least one belt shoulder portion of the seat belt (1a, 1c, 1e) is extended over the corresponding open aperture of the shoulder cap and loosely secured in the open aperture of the respective latch plate.

5. The restraint system according to claim 2, wherein the shoulder cap (10.2e), recessed about a supporting tube (3.61) of a head rest (3.6), is reinforced by a reinforcing plate (10.13).

6. The restraint system equipped with a shoulder- and neck holder according to claim 2, further comprising a neck holder, having a pair of neck caps (10.4, 10.4b), attached to the pair of shoulder caps (10.2e), to restrain the passenger's neck in the operative position.

7. The restraint system according to claim 6 wherein the drive apparatus (80) is activated by a separately operated switch.

8. The restraint system according to claim 6, wherein the drive apparatus is activated by a controller, monitoring the speed, in excess of a threshold speed.

9. The restraint system according to claim 6, wherein the drive apparatus is activated by an accelerator pedal.

10. The restraint system according to claim 6, wherein the drive apparatus is activated when a sensor senses an acceleration, which exceeds a threshold acceleration.

30 11. The restraint system according to claim 6, wherein upon a pressure on a release button (87a to 87c) of the seat the drive apparatus (80) moves the shoulder- and neck holder back from the operative position to the resting position.

35 12. The restraint system according to claim 6, wherein the lap buckle assembly (9.1) has a master release button (84), which is connected to switches of the drive apparatus (80) and electrical motors (4.2b) of the remaining buckle assemblies of the seat belt via respective deactivating cables, where the master release button (84), when depressed, disengages all the latch plates and moves the shoulder- and neck holder back from the operative position to the resting position.

13. The restraint system equipped with a shoulder- and neck holder according to claim 3, further comprising  
a neck holder, having a pair of neck caps (10.4, 10.4b), insertably attached to the pair of shoulder caps (10.2, 10.2b, 10.2f), to restrain the neck upon use,  
5 where the neck caps can be detached therefrom and removed.
14. The restraint system according to claim 13, wherein the shoulder- and neck holder (10, 10b, 10f) is provided with at least one energy absorber (10.3, 10.3a, 10.5, 10.5a, 10.5c).
15. The restraint system according to claim 14, wherein the energy absorber is fastened to the cap by an adhesive fastener and detachable therefrom by opening the fastener.  
10 16. The restraint system according to claim 3, wherein the shoulder cap is shoulder-shaped.
17. The restraint system according to claim 14, wherein the energy absorber is shoulder-shaped.  
18. The restraint system according to claim 13, wherein the neck cap is neck-shaped.  
19. The restraint system according to claim 14, wherein the energy absorber is neck-shaped.  
15 20. The restraint system according to claim 19, wherein the energy absorber (10.5a), arranged in the neck cap (10.4a), serves as a neck collar having a wide portion for the chin.  
21. The restraint system according to claim 3, wherein the latch plate of the holder is provided with an energy absorber (10.9).  
22. The restraint system according to claim 13, wherein the shoulder- and neck cap, provided with a flange (10.12), is adjustable in height by rotating a bolt (10.7) in a threaded hole of the flange (10.12).  
23. The restraint system according to claim 13, wherein the shoulder- and neck cap, provided with a flange (10.12f), is adjustable in width by rotating a bolt (10.6a) in a threaded hole of the flange (10.12f).  
25 24. The restraint system equipped with the shoulder- and neck holder and with vibration-dampening energy absorbers according to claim 13, further comprising at least one vibration-dampening energy absorber (30, 40, 50), which consists of  
a retaining element (31, 41, 51), serving as a member of a seat frame, generally representing a seat-cushion- or seat backrest frame, and  
30 at least one clamping element (32, 32.1 to 32.n, 42, 42.1 to 42.n, 52, 52.1 to 52.n), connected to the buckle assembly of the seat by means of at least one control-wire (37, 47, 57), biased, arranged along the retaining element and provided with sites of predetermined fracture (s), which have at least one threshold value.  
25. The restraint system according to claim 24, wherein the retaining element is integrated into the seat frame.  
26. The restraint system according to claim 24, wherein the clamping element has open and tube-shaped profile.  
27. The restraint system according to claim 24, wherein the retaining element is tube-shaped.

28. The restraint system according to claim 24, wherein a longitudinal rib (41.1, 51.1) is arranged to the retaining element.

29. The restraint system according to claim 28, wherein both edges of the clamping element are loosely guided by the longitudinal rib in longitudinal direction.

5 30. The restraint system according to claim 28, wherein a stop element (41.3) is arranged to the longitudinal rib.

31. The restraint system according to claim 28, wherein the thickness of the longitudinal rib increases in longitudinal direction, in which the clamping element moves.

10 32. The restraint system according to claim 24, wherein the clamping element is cone-shaped.

33. The restraint system according to claim 24, wherein the retaining element (51) is cone-shaped.

15 34. The restraint system according to claim 24, wherein at least one stop pin (46, 46.1 to 46.n) is laterally arranged to the retaining element, where the stop pin blocks a movement of the clamping element, thus resulting in fracture of the sites of predetermined fracture.

35. The restraint system according to claim 24, wherein contact surfaces of the retaining element have arbitrary friction coefficients ( $\mu_0$ ).

20 36. The restraint system according to claim 24, wherein contact surfaces of the retaining element are provided with a soundproofing material (83).

37. The restraint system according to claim 24, wherein contact surfaces of the clamping element have arbitrary friction coefficients ( $\mu_0$ ).

25 38. The restraint system according to claim 24, wherein contact surfaces of the clamping element are provided with a soundproofing material (83).

39. The restraint system according to claim 29, wherein end portions of a complementary wires (37a1), connected to the control-wire (37), are inserted into both cylinder-shaped edges (37c1) of the clamping elements (32) and secured by clamping the cylinder-shaped edges (37c1).

40. The restraint system according to claim 24, wherein the clamping element is provided with a pair of ribs, whereto several pairs of adjusting holes ( $L_1$  to  $L_e$ ) are arranged.

30 41. The restraint system according to claim 24, wherein a set of vibration-dampening energy absorbers comprises the retaining element, at least one stop pin, at least one stop element, one control-clamping element, connected to the control-wire, and complementary clamping elements with/without sites of predetermined fracture, where all clamping elements, arranged along the retaining element, are tautly, less tautly and/or loosely connected to each other by means of complementary wires.

35 42. An energy-absorbing, vibration-dampening device according to claim 41, comprising a couple member (1.2a, 1.2b) and the sets of vibration-dampening energy absorbers, the control-wires of which are tautly, less tautly and/or loosely connected to the couple member.

43. The restraint system according to claim 42, wherein a guide piece (4.7a), fastened to the seat frame, has

a pair of engaging parts (4.10a), form-locking connected to the corresponding apertures of a housing (4.8a) of the buckle assembly; and

5 a recess (4.5a) to loosely guide a tie band (1.1a), having a first and second end connected to the buckle assembly and the couple member.

44. The restraint system according to claim 42, wherein a guide piece (4.7b), fastened to the seat frame, has

10 a pair of engaging parts (4.10b), form-locking connected to the corresponding apertures of a housing (4.8b) of the buckle assembly; and

a longitudinal groove (4.5b) to loosely guide a tie band (1.1b), having a first and second end connected to the buckle assembly and the couple member.

45. The restraint system according to claim 42, wherein a housing (4.8c), movable along a pair of tubes (27.3) of the seat backrest frame and latchable thereon, has

15 an aperture to receive an engaging part (4.10c) of the buckle assembly, through a hole (2.3) of which a wire is protruded and both end portions of the wire, serving as tie bands, are secured by a mutual bracket (1.7); and

two holes (4.5c) to loosely guide the tie bands, connected to the couple members.

46. An anti-submarining seat-belt assembly to absorb energy and dampen vibrations in the

20 real-world accident, a rollover or the turbulence-related vibrations according to claim 43, wherein the lap belt portion (1.3) of the seat belt (1d, 1e), provided with at least one movable anti-submarining latch plate (11, 25), is subdivided into two anti-submarining belt portions; which restrain both thighs of the passenger upon plug-in connection of the movable anti-

submarining latch plate (11, 25) with one of anti-submarining buckle assemblies (7, 8, 8a)

25 of a seat cushion, whose frame is equipped with the guide pieces (4.7a) and the energy-absorbing, vibration-dampening device;

where release cables (4.2) connect release buttons of the submarining buckle assemblies to a common release button (84o), located on the seat cushion, which, when depressed, disengages the movable anti-submarining latch plate (11, 25) while the restraint of the

30 belted passenger remains unaffected.

47. The restraint system according to claim 13, wherein the lap buckle assembly (9.1) has a master release button (84);

which is connected to release buttons of the remaining buckle assemblies of the seat belt and to release buttons of the pairs of buckle assemblies, to one of which the latch plates of the

35 holder are plug-in connected;

where the master release button (84), when depressed, disengages all the latch plates of the holder and seat belt.

48. The restraint system according to claim 3, wherein the shoulder holder is attached to the seat for the purpose of storage and detachable therefrom by depressing a release button (87a to 87c) of the seat.

49. The restraint system according to claim 13, wherein the shoulder- and neck holder is attached to the seat for the purpose of storage and detachable therefrom by depressing a release button of the seat.

50. An energy-absorbing, vibration-dampening safety seat according to claim 49, wherein sets of vibration-dampening energy absorbers, the seat belt, holder and seat are integrated into a safety adult-seat;

5 which is transformed into a safety child-seat when a detachable front portion of the seat cushion (3.1a) serves as a shoulder- and neck holder (10a), the latch plates of which are plug-in connected to one of the pairs of buckle assemblies (18a / 19a to 18n / 19n) of the seat backrest, to restrain shoulders and a neck of a belted child and the space thereof is exploited to accommodate legs of the child sitting on the rear portion thereof, where the safety child-seat can be converted back into the safety adult-seat.

10 51. An energy-absorbing, vibration-dampening safety baby-cot according to claim 50, wherein

the safety child-seat is transformed into a safety baby-cot when the seat backrest is flipped downwards;

15 where the safety baby-cot can directly be converted back either into the safety child-seat or into the safety adult-seat.

52. The restraint system according to claim 46, wherein the lap buckle assembly (9.1) has a master release button (84),

20 which is connected to release buttons of the remaining buckle assemblies of the seat belt and to release buttons of the pairs of buckle assemblies, to one of which the latch plates of the holder is plug-in connected, as well as to the release buttons of the anti-submarining buckle assemblies,

where the master release button (84), when depressed, disengages the movable anti-submarining latch plate and all the latch plates of the holder and seat belt.

## ABSTRACT

A shoulder- and/or neck-holder, seat-belt, seat and sets of vibration-dampening energy-absorbers are integrated into an energy-absorbing, vibration-dampening safety-seat in order to restrain the shoulders and/or neck of a belted passenger, dampen vibrations and gradually absorb subenergies, resulting from a subdivision of the total energy, just below the respective injury-irrelevant threshold-values in any real-world accident of a transport-system, 5  
submarining or during in-flight turbulence. The conversion of an adult-seat into a child-seat or a baby-cot or vice-versa is simple. A rotatable device makes the holder easy to use.

10 Neck- and/or shoulder-shaped, height-, width-adjustable holders and/or neck- and/or shoulder-shaped energy absorbers, attached thereto, ensure complete restraint of the shoulders and necks of passengers with different weights and body-proportions.

15 For the convenience of the passenger or in cases of emergency all latch-plates are disengaged from the buckle-assemblies and/or the rotatable holder is repositioned to the resting position on depression of a master release-button.

## OTHER PUBLICATIONS

- [1] Car-Magazine ADAC 1/95
- [2] Car-Magazine AMS (Auto Motor und Sport) 23/97
- 5 [3] Car-Magazine AMS 12/99, Newspapers Wiesbadener Kurier of 28.12.98, 20.01, 22.06, 04.11.99, Frankfurter Allgemeine Zeitung of 08.09.99, Frankfurter Rundschau of 12.06.99
- [4] Wiesbadener Tagsblatt of 28.12.97 reporting 100 injured passengers, 10 of which severely, during turbulence-related vibrations of an aeroplane Boeing 747.
- 10 [5] Wiesbadener Tagsblatt of 15.04.99 reporting 30 injured passengers during turbulence-related vibrations of an aeroplane Boeing 747.
- [6] Police accident report and photos documenting the steering wheel and -column totally deformed by the head, thrown forward, of a 34 years-old driver of a brand-new German luxury car.
- 15 [7] Police accident report and accident report by Go documenting the instant death of a 34 year-old female driver in a German premium sport car, into which a smaller Japanese car crashes in the city Wiesbaden, due to the head impact with the window pane and whiplash.
- 20 [8] 34-page accident report by Go concerning severe/fatal injuries, submarining, head impacts and whiplash resulted from failure of conventional seat belts etc. to four German Ministers, General Attorney, Vice General Attorney, Senior Attorneys, Police Chief Directors, Police Directors etc.

25

## SHOULDER- AND NECK HOLDER

### CROSS REFERENCE TO RELATED APPLICATIONS

This is an international application number PCT/DE98/03271 (WO 99/24292, European Patent EP 1 037 771 B1, German Patent DE 197 58 498 C2) filed Nov. 10, 1998 and claiming the priority of DE 197 58 498 A1 filed Nov. 11, 1997.

#### 1. Field of the Invention:

The present invention relates generally to a shoulder- and neck holder, which restrains the shoulders and neck of a belted passenger, an anti-submarining seat-belt assembly as well as a safety seat in order to dampen vibrations and substantially reduce the acceleration-depending loads below the injury-related values

- in an event of arbitrary accident of a vehicle, train or an aeroplane or
- in an inflight turbulence.

#### 15 2. Discussion of the Related Art:

It is known in the prior art to provide

- a three-point seat belt (safety belt or lap-shoulder seat belt) consisting of a shoulder belt extending across the torso and of a lap belt extending across the lower part of body in motor vehicle;
- a two-point seat belt acting as lap belt extending across the lower part of body in an aeroplane or a rear seat of vehicle or
- a seat-belt substitute for restraining the shoulders, upper part of the body and/or neck.

In order to formulate in single terminology a generalized definition for the proper term is

25 presented:

*"belt portions 1.1, 1.2, 1.3 and 1.4"* for members of a multi-point seat belt **1a to 1d** (Figs. 1, 14) ref. to EP 1 037 773 B1 (WO 99/24294, PCT/DE98/03270, DE 197 49 780 C2). The upper part of body is restrained by extending the shoulder belt portions **1.1, 1.2** crosswise in an „X-shape” while the lower part of body is restrained by the lap belt portion **1.3**.

30 *"belt portions 1.2, 1.3 and 1.4"* for members of a three-point belt **1e** to restrain the upper part of body and to restrain the lower part of body, shown in **Fig. 14**;

"*belt portion 1.3*" for conventional two-point or lap seat belt;

"*floor 6*" for vehicle-, train- or aeroplane floor (Fig. 14);

"*seat frame*" for frame of seat backrest or seat-cushion;

"*accident*" of a vehicle, train or aeroplane for front-, side-, rear collision of a vehicle or pile up

5 (mass accident) or for train-, aeroplane accident or turbulence-related vibrations of an aeroplane;

"*energy-absorption*" for absorption and release of impact energy as well as dampening vibrations;

"*undamped energy-absorption*" for absorption and release of impact energy while vibrations 10 are undamped;

"*energy-absorbing method*" for gradually absorbing subenergies „ $\Delta F_i$ ”, the addition of which is equal to total energy „ $F_n$ ” or belt force (Fig. 9) and the increment  $i$  of which increases from 1 to  $n$ , below the respective injury-related values by undamped energy-absorption, energy-absorption, preserving the clamping and friction forces of control-clamping 15 elements associated with the fracture of the sites of predetermined fracture of clamping elements and energy absorbers during the energy-absorption, thus enhancing the survival chance and ensuring the restraint below the tensile strength of seat belt.

It is well known to restrain passengers, particularly, of vehicles with seat belts in the event 20 of accident, where a small forward motion of the upper part of body at low speed is acceptable. However, in the crash tests at speed of 55 km/h the rotating masses of torso **95.2** and head **95.1** are thrown forward and twisted by the acceleration-dependant loads [1, 2, 6 to 8].

Due to lack of restraint systems in trains passengers are not restrained, thus subjected to 25 severe or fatal injury when ejected from the seats in accidents.

It is well known to restrain passengers of aeroplanes by two-point or lap seat belts, which are incapable of restraining the upper part of body as well as head in accidents, particularly associated with sudden turbulence. Consequently, severe/fatal injuries have been reported and, for sure, will be reported in the future.

30 Ref. to US 2,833,554 a passenger, sitting on the seat, is restrained by a head shielding plate, chest shielding plate and at least one knee shielding plate, all of which are provided with arms

pivottally mounted to a column fastened to the vehicle roof and tunnel. US 3,392,989 has the same feature.

US 3,713,694 teaches a pair of rotatable U-shaped shoulder-arms, connected to each other by an upper crank shaft transversely arranged in the upper portion of the seat backrest, and a

5 lever arm, which, adjacent to the side of the seat cushion, is connected to a rotatable lower crank shaft, transversely arranged to the rear portion thereof and loosely connected to the upper crank, by a connector. When the lever arm is moved downwardly, the upper crank rotates the U-shaped shoulder-arms downwardly to restrain the shoulders of a passenger, sitting on the seat. DE-OS 2152146 has the same feature.

10 US 3,829,158 addresses a body-restraining device comprising a rotatable U-shaped hook, both ends, provided with a pair of pivots and arranged in the seat backrest. When rotating from a resting position, in which the U-shaped hook is located above the head, to an operative position the U-shaped hook envelopes the upper part of the body of a passenger sitting on the seat.

15 Ref. to US 4,700,632 a passenger, in a standing position on a roller coaster, is restrained by a device comprising a seat placed between his legs, a back member, into which a head rest is incorporated, and a pair of arms, one of which remains fixed and the other is movable, defines a harness for retaining the upper part of his body.

20 US 5,529,382 addresses an over-shoulder-rotatable operating device, permitting fine adjustments of two pairs of pivoting arms to a body proportion, for amusement attractions. The device comprises a lower plate, resting against the passenger's abdomen and the pairs of pivoting arms, the first pair located behind and above the passenger's shoulders and the second pair in conjunction with the lower plate in front of the passenger.

25 Ref. to EP 0003354 A1, equivalent to DE-OS 2803574, a seat backrest has a pair of recesses at the seat sides to house a pair of rotatable legs of a U-shaped seat member in a resting position. In an operative position the legs are rotated vertically, thus facilitating the U-shaped seat member to restrain a child. sitting on the seat.

30 According to the above-listed patent documents US 2,833,554, US 3,392,989, US 3,713,694, US 3,829,158, US 3,901,550 (DE-OS 24 28 285), US 4,700,632, US 5,529,382, DE-OS 2152146 and EP 0003354 A1 (DE-OS 2803574) a restraint device, substituted for a seat belt (restraint system), restrains the shoulders, lap and/or abdomen of a passenger. This

feature is in contradiction to the law, valid world-wide, enforcing the use of seat belts during travel. Unbelted passengers are not tolerated. Police fine them for belt violations. Recently, in Washington State a hefty \$ 86 fine per passenger, imposed therefor, is legislated. Furthermore, Administrations world-wide would reject motor vehicles, equipped with such restraint devices,  
5 thus putting the car manufacturer out of business.

Moreover, all the restraint devices need space, the design is bulky and unattractive. By no means can child-seats and/or baby cots be installed in the car. The overall stylish impression of the vehicle is not beneficial to sales. When cleaning, repairing or stepping in or out of the vehicle body, the passengers, in particular, children can stumble over such devices,  
10 unintentionally hit them and/or be obstructed, for example, by the seat harnesses, located in the resting position at the head level, ref. to US 3,392,989. Evidently, all the restraint devices are incapable of absorbing great energy, dampening strong vibrations, ensuring the restraint of the passengers in any real-world accident, for example, submarining, rollover, multi-crash etc. As a result, passengers are exposed to the danger of being severely/fatally injured and/or burnt alive  
15 if the car catches fire.

According to US 3,901,550, that has the best feature among the above-mentioned restraint devices, the passenger is secured by the restraint of both shoulders and the pelvis **96** by means of two pairs of air-cushioned guard arms **16** and **18**. The following problem cases cast doubt on the survival chance and applicability:

20 I. Due to the gap „*s<sub>i</sub>*” between the shoulders and shoulder cap the shoulders and head **95.1** can oscillate. High injury severity results from

1. large acceleration of head of a belted dummy about 83 g in the crash test of a vehicle without airbag [1],
2. limited energy-absorption property of the air chambers to dissipate large energy of the upper part of body of belted dummy, thrown forward, by a force of about 64 g and
- 25 3. lack of neck cap to dissipate large energy of the head, yaw-accelerated at the yaw angle **O** [2], acting as the second rotating mass.

A passenger, submarining (slipping downward) in a rear collision, releases himself from the restraint by the guard arms **16** and **18**, thus exposed to severe/fatal injury.

30 In a real-world accident, the load cases of which are illustrated in **Figs. 1 and 2**, the survival chance is low due to lack of energy- and shock absorber.

II. Upper part of body, defined by various outer contour from **SC1”** to „**SC3”**, for example, upon putting a thick winter coat, can't be retained because only one outer contour „**SC2”** is

configured when pulling together the air chambers 26 of guard arms 16 via a tension strap 30. The outer contour is determined by two body shapes (both shoulders and chest) and the passenger, whose circumference varies depending on the clothes worn.

III. The manufacturing costs for two pairs of guard arms and two feeding systems are higher  
5 than that of the shoulder- and neck holder including the seat belt.

IV. Passengers are severely/fatally injured in the event of submerging or rolling over.

According to DE 37 06 394 C1 a backrest of a front vehicle seat is equipped with deformation elements, which are deformed beyond the yield limit for the purpose of undampened energy-absorption when

10 – a passenger, seated in the front, is thrown against the seat backrest in a rear collision or  
– an unbelted passenger, seated in the back, is thrown against the seat backrest in a front collision.

The supporting members of the seat backrest frame serve as deformation elements, to which expanding and contracting elements are arranged, the geometry of which and elastic limit of  
15 which vary along the length of the seat backrest.

Ref. to DE 42 38 549 A1 thin walls of a seat backrest frame are proposed for undampened energy-absorption.

According to DE 92 02 219 U1 a belt retractor, equipped with a clamping device, acts as delimiter of a restraint system in conjunction with deformation and energy-absorption. The belt  
20 retractor and clamping device are connected to each other by a plate with ribs. Due to clamping of the belt in excess of a threshold value the ribs are deformed, thus increasing the distance of the clamping device from the belt retractor. The energy, imposed on the belted passenger, is released by the fracture of predetermined sites of the ribs.

A seat ref. to EP 04234348 A1 is proposed for survival chance in a mid-front collision of car,  
25 train or aeroplane. A pair of energy absorbers is pivotally attached to a pair of front and rear seat legs, which are pivotally attached to the floor 6 and a seat-cushion frame. Each energy absorber consists of a rod, pivotally attached to the rear seat leg and floor 6 and having a cone-shaped end, and a tube, pivotally attached to the front seat leg and seat-cushion frame and having a cone-shaped collar to receive the end of the rod. During the movement of the seat in  
30 mid-front collision, the end of the rod expands (reams) the tube, thus performing work of

deformation and friction in order to dissipate energy. For the purpose of gliding the end of the rod along the inner cylinder of the tube, the wall may not be cracked, but only deformed.

Exemplified by DE 39 33 721 A1, another energy-absorbing friction device, mounted to a vehicle part, has a tube, which is deformed by the belt force. The end of a rod, protruding through the tube, is connected to the seat belt and several barrels of a role (bearing balls) are arranged around the other end, inserted in the inner cylinder of tube. The outer diameter of the rod and barrels of a role is a little larger than the inner diameter of tube. Under the load of belt force the barrels expand the inner cylinder of tube.

A very low work of deformation and friction is achieved, nevertheless, this invention contains the first-promising feature which only in co-operation with the seat belt is able to effectively absorb energy.

US 5,544,918 discloses an energy-absorbing management device, which comprises a crushable (deformable) honeycomb to absorb energy and a controller consisting of three-sensor mechanisms to monitor and sense the weight of the passenger, his forward motion and the severity of the vehicle collision. Unfortunately, sensors are incapable of evaluating crash data within few milliseconds and responsible for false deployment of airbags, resulting in decapitations, severe/fatal injuries and burns, which are reported in [6 to 8] and EP 0844939 B1 (US 09/125,455). Due to the unreliable operation of sensors car manufacturer has no choice to start recall program, which impairs the reputation and is costly.

A more reliable and far cheaper energy-absorbing device is described hereinafter and in DE 197 58 497 C2.

#### SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to provide for a belted passenger a transport system a shoulder- and neck holder which resolves the above-mentioned shortcomings and deficiencies, dampen vibrations and decreases all the loads below the injury-relevant threshold values in the event of a real-world accident, shown in **Figs. 1 and 2**, or in an inflight turbulence.

A second object of the present invention resides in emergency operation by means of a common release button, when depressed, either to release all the all latch plates of the insertable shoulder- and neck holder from the respective buckle assemblies or to move a

rotatable device of the rotatable shoulder- and neck holder back from the operative position to the resting position. By law passengers travelling in a motor vehicle or experiencing flight-turbulence must remain belted. The need for a belted mother to turn around becomes apparent, because she must attend to her belted children crying and sitting on the rear seat.

5 A third object of the present invention resides in one-click operation by means of a master release button, when depressed, to release the main latch plate and all the additional latch plates from the main and supplemental buckle assemblies, either to release all the all latch plates of the insertable shoulder- and neck holder from the respective buckle assemblies or to move the rotatable device of the rotatable shoulder- and neck holder back from the operative 10 position to the resting position. In emergency cases paramedics and fire-fighters can easily rescue the injured passengers. Within seconds the passengers can step out of the transport system when catching fire.

A fourth object of the present invention resides in a cost-, space-saving integration of the a 15 seat belt, the insertable shoulder- and neck holder, energy absorbers, sets of vibration-dampening energy absorbers, an anti-submarining seat-belt assembly and the seat into an energy-absorbing, vibration-dampening safety seat, which can be converted into a safety baby-cot 86, safety child-seat 85a, 85b or safety adult-seat 85a to 85e or vice-versa, illustrated in Fig. 14. As a result, the rate of seat occupancy in a bus, train or an aeroplane is increased and there is no need to purchase child-seats and baby-cots and transport them, when not used, back 20 anymore.

#### INDUSTRIAL APPLICABILITY

It should be apparent that the invention provides a substantially improved restraint including 25 the following features:

– In compliance with the law, valid world-wide, enforcing the use of seat belts by the use of the conventional or newest seat belt ref. to WO 99/24294, the restraint of shoulders and/or neck by the shoulder- and/or neck holder can be determined before the travel/flight or in accident/turbulence or in excess of a threshold speed e.g. over 80 km/h. The deflecting 30 point or end of a conventional seat belt 3e (Fig. 14) is located at the top edge of seat backrest. The compound of two restraint systems 1c / 10, 1a / 10a, 1b / 10b, 1d / 10d, 1e / 10e minimizes movements/motions/torsions and all acceleration-dependant loads (Fig. 1),

imposed on shoulders, neck, torso, the lower part of body and, in particular, head acting as the 2nd mass.

- The upper part **95** of body consists of torso **95.2** and head **95.1**. In the z-y and x-y plane (Fig. 1) the pitch- and yaw angle  $U_S$  and  $O$  of the 1st mass of torso about the rotating „S”- and z-axes converge toward zero owing to the restraint of shoulders of the belted torso, thus reducing the forward motion, pitch acceleration  $\ddot{U}_S$ -,  $\ddot{U}_H$ - and yaw acceleration  $\ddot{O}$ -dependent forces  $F_{Sy}$ ,  $F_{Hy}$  and  $T$  in arbitrary front collision. Analogously, the forces  $T$ ,  $F_{Sx}$ ,  $F_{Ix}$  and/or  $F_{Sz}$  are reduced in arbitrary side collision and/or rollover. This feature contributes to new development to increase the reliability of substitutes for airbags. Due to the unreliability and false deployment of airbags newspapers [3] have reported recall programs, decapitations, severe/fatal injuries, burns etc.
- Beyond doubt, one-piece neck cap **10.4a**, **10.4c**, rigidly connected to shoulder cap **10.2a**, **10.2c**, sustains the neck e.g. of a cervical trauma suffering passenger at the best. If such shoulder- and neck holders **10a**, **10c** were installed in a vehicle or an aeroplane, healthy passengers would reject to use them when it is hot or the passenger is wearing tie or jewellery around her/his neck. This controversy is resolved by the features of one the Claims 1 to 4 in association with Claim 13.
- By making the caps **10.2**, **10.2a** to **10.2f** and a number of the respective alternate energy absorbers **10.3**, **10.3a** even a passenger with broad shoulders can use the holder by changing shoulder caps.

Moreover, the overall stylish impression of seats is spoilt by shoulder- and/or neck-shaped caps, when not in use, thus impairing the sales. Understandably, the design of caps of holders e.g. **10**, **10b** (Fig. 14) for expensive luxury cars depends, principally, on the form of the seat **3c**, **3b**. It is more likely that seats of expensive luxury cars are equipped with shoulder- and neck holders **10d**, **10e** (Figs. 1, 8), which are located in the seat backrests when not used. To protect the broad shouldered passenger the shoulder caps must be changed. The decision for shoulder- or seat -shaped caps depends on the purpose of holders installed in the motor vehicle (bus, ambulance, van, luxury car etc.), train and aeroplane. This controversy is resolved by the features of one the Claims 16 to 20.

- The problem case II, aforementioned, is resolved by variable restraint of a single body member comprising the shoulders and neck. Preferably, one- or two-piece, shoulder-shaped energy absorbers **10.3**, **10.3a** can be detached from one- or two-piece, deformable caps

**10.2, 10.2a to 10.2f** and one- or two-piece, neck-shaped energy absorbers **10.5, 10.5a, 10.5c** from one- or two-piece, deformable caps **10.4, 10.4a to 10.4c, 10.4f** as well as fastened thereto via adhesive fastener such as zip-, snap-in- or Velcro fastener. The absorber as well as cap can be made of one- or two pieces.

5 For the purpose of cost saving associated with the demand for passengers, with different neck- and shoulder shapes, a large number of neck- and shoulder-shaped energy absorbers **10.3, 10.3a, 10.5, 10.5a, 10.5c** and a low number of caps are produced. **Fig. 14** exemplifies the adaptation of the holder to the body proportion of a child, sitting on the seat **3a, 3b**, by using detachable holder **10a, 10b**.

10 – For the purpose of quick storage and removal, the holder **10a to 10c** is inserted into the seat backrest or -cushion of seat **3a to 3c** (**Fig. 14**), secured by inserting the pair of latch plates **10.1, 10.1b, 10.1f** therein and released by pressing the release button **87a to 87c**. Both latch plates of shoulder- and neck holder **10a** are disengaged from seat cushion **3.1a** (**Fig. 14**) by pressing the release button **87a**. As front portion of that seat cushion the holder **10a** is removed from the cutaway portion (opening) to exploit its space for accommodation of both lower legs of a child sitting on the rear portion thereof.

15 – For the convenience of the passenger and in cases of quick-rescue and emergency a master release button **84** of lap buckle assembly **9.1** is pressed to release all latch plates of the seat belt from the respective buckle assemblies and

20 \* to move the holder **10d, 10e** back from the operative position to the resting position or  
\* to release all latch plates of holder **10, 10a to 10c, 10f** from the respective buckle assemblies.

25 – Both casings **29a** of rotatable device **28a** are guided by two pairs of inner tubes **71, 72** of seat backrest frame **3.4d, 3.4e** and can be locked in the required height.

30 – Large impact energy is absorbed, during which vibration is damped, by  
\* fracture of pads of predetermined fracture „S<sub>11</sub>” to „S<sub>mn</sub>” and „H<sub>11</sub>” to „H<sub>nm</sub>”, which define the energy absorber **10.3, 10.3a and 10.5, 10.5a, 10.5c**;  
\* fracture of sites of predetermined fracture „s” of spring **10.9**;  
\* fracture of sites of predetermined fracture of clamping elements of the following sets of energy absorbers **30, 40, 50** (**Figs. 10 to 12**) having control-wires **37, 47, 57**, representing **40e, 40f** having wires **47e, 47f**, which are tautly, less tautly and/or loosely connected to holder **10e**; and

\* friction of clamping elements **32.1 to 32.e, 42.1 to 42.e, 52.1 to 52.e**, which move along the respective retaining elements **31, 41, 51**.

– The shoulder- and/or neck cap can be inserted or rotatably attached to or in the seat backrest. Furthermore, it can be adapted to the body proportion of a passenger by a width- and height-adjustable mechanism of the holder.

5 The sets of energy absorbers and accommodation thereof in the frame of seat backrest and/or seat cushion account for a method of construction to save space, weight and costs and to increase stiffness. Furthermore, the energy-absorbing elements are made by extrusion, depth extrusion, casting, die casting or of spring plate or of spring steel. A

10 preference for the embodiments is given to elements, having round profile, which are the cheapest and easiest to manufacture.

The costs and reject rate are lowered by a single tolerance (over- or undermeasure of a round profile), pre-tensioning (biasing) the clamping elements on or in the retaining element and pre-assembling all sets of energy absorbers, which are pre-loaded, for the delivery and 15 final assembly to the frame of seat backrest and/or seat cushion.

The position of clamping elements e.g. **42, 42.1, ..., 42.n** to each other can be adjusted by choosing the adjusting holes „ $L_1$ “ to „ $L_e$ “ and/or by clamping the brackets **37b1** on the wires.

20 Owing to the property of the great energy-absorption by small mass, lighter materials such as magnesium-, aluminium-extrusion, die casting of GD-MgA12 or alloys or carbon/glass fibre-reinforced plastics, used for skis, are recommended for the caps of the holder, latch plates and parts of the set of energy absorbers.

– Fracture of sites of predetermined fracture „s“ can be used as court-evidence for a passenger having belted in the accident.

25 – Retaining elements (**Figs. 1, 10, 11**), integrated into the frame of seat backrest and/or seat cushion, enormously increase the stiffness of seat. The buckle assemblies, receiving the latch plates, are sustained by the frame of seat backrest and/or seat cushion. Advantageously, retaining elements such as **31c** can be exploited as the seat legs of the seat **3c** (**Fig. 14**).

– Two- or three-point seat belt can be equipped with sets of energy absorbers. The guide pieces of buckle assemblies, plug-in connected to the respective latch plates, have two 30 functions to integrate energy absorbers into the two-, three- or multi-point seat belt and to guide the movement of the buckle assemblies, when loaded or unloaded.

- Due to the increased tension on the wire the clamping element performs the work of deformation and friction, which is released in excess of threshold value resulting in fracture of sites of predetermined fracture „s”, two sites shown in **Fig. 11**, upon the contact with both heads of stop pin or bolt **46.1, ..., 46.n**. The site of predetermined fracture can be formed as crack, corrugation, hole or recess.  
5
- In another embodiment the performed work (energy) is released by fracture
  - \* in excess of the yield limit of the clamping element,
  - \* due to constrained deformation of carrier piece or expanding (reaming) the clamping element upon the contact with a wedge-shaped stop element **41.3** (**Fig. 11**) or with a wedge-shaped rib **41.1, 51.1** (**Fig. 12**).
- Generally, the energy absorber consists of a tube-shaped base body with/without rib, serving as retaining element, and at least one clamping element, which is arranged to or in the retaining element. Wires are employed to tautly, less tautly and/or loosely connect
  - \* clamping elements to each other, whereby a row of energy absorbers e.g. **R42** (not denoted) is defined from the expanding clamping elements **42, 42.1 to 42.n** and the retaining element **41** (**Fig. 11**). In similar manner the other rows of energy absorbers such as **R32, R52** etc. can be built together;
  - \* rows of energy absorbers to define a set of energy absorbers **30, 40, 50** (**Figs. 10 to 12**) and
  - \* sets of energy absorbers to couple member **1.2a, 1.2b** of tie band (catch band) **1.1a, 1.1b, 1.5, 1.6, 47e, 47f** (**Figs. 1, 13a to 13c**) to dissipate subenergies „ $\Delta F_i$ ” by applying the energy-absorbing method.

Injury-irrelevant threshold value is defined by the difference between two forces „ $\Delta F_i$ ”, lower than the injury-related load. The threshold values may have different magnitudes.  
25 For the energy-absorption up to the starting threshold value „ $\Delta F_1$ ”, at least one clamping element **42e, 42f** (**Fig. 1**) or energy absorber **10.3, 10.3a, 10.5, 10.5a, 10.5c** is responsible. In order to prevent vibration and to fix the onset of energy-absorption at least one control-clamping element **52** must be biased up to an onset force-level e.g. „ $\Delta F_1 - 500 \text{ N}$ ”, which is lower than „ $\Delta F_1$ ”. Over this onset force-level the element, pulled by the corresponding wire **57**, performs work of deformation and friction, during which the energy „ $\Delta F_1$ ” is released by fracture of sites of predetermined fracture of clamping element **42e, 42f**, so that the passenger is neither injured nor thrown back. The energy increase about „ $\Delta F_2$ ” is  
30

compensated by the fracture of at least one complementary clamping element **52.1 to 52.n**, so that the passenger is neither injured nor thrown back.

The gradual reduction of energy is repeated so long up to a load zone defined of „ $\Delta F_e$  - 500 N”, in which all clamping elements are broken, the control-clamping elements **52** cannot move anymore and at least one control-clamping element **42**, biased at „ $\Delta F_f$  - 500 N”, and/or at least one clamping element of set of energy absorbers **40** perform(s) work of deformation and friction.

The energy increase about „ $\Delta F_f$ ” is compensated by the fracture of the control-clamping elements **52** and/or of at least one complementary clamping element **42.1 to 42.n**, so that the passenger is neither injured nor thrown back. The gradual reduction of energy is repeated so long till

1. the total energy „ $F_n$ ” is consumed or
2. a new load zone defined of e.g. „ $\Delta F_h$  - 500 N”, in which all clamping elements are broken, the control-clamping elements **42** can't move anymore and at least one of the following sets of energy absorbers decrease energy, such as
  - \* **30, 40a, 50a** (not shown) of the other structural half of seat-cushion frame **3.3a**,
  - \* **40, 50** of the other structural half of seat backrest frame **3.4a**,
  - \* **30M, 40M, 50M, 65M** (not shown) fastened to the cross members **3.41, 3.42** of seat backrest frame **3.4a** facing each other,
  - \* **30N, 40N, 50N, 65N** (not shown) fastened to the cross members **3.31, 3.33** (not shown) of seat-cushion frame **3.3a** facing each other.

Because the passenger was subjected to a succession of injury-irrelevant threshold values „ $\Delta F_i$ ”, where  $i = 1$  to  $n$ , during the accident and restrained by the seat belt, tensile strength of which about 24,000 N is substantially higher than „ $\Delta F_i$ ”, he needs only to depress the master release button **84**, detaching all latch plates from buckle assemblies, and egresses, unscathed, from the vehicle, train or aeroplane (Figs. 1 and 14).

An energy-absorbing device, comprising a number of sets of energy absorbers, having different threshold values, is connected to the holder and to the latch plates of the seat belt in plug-in connection with the buckle assemblies of the seat backrest and/or -cushion.

30 – In another embodiment a sound-proofing material **83**, having arbitrary friction coefficient  $\mu_0$ , different or progressive friction coefficient, is attached to the contact surface of retaining element and/or clamping element for the purpose of dampening vibration and performing

work of friction. Furthermore, it is possible to coat the retaining elements and corresponding clamping elements, thus eliminating any noise.

- In the event of submerging and/or rollover the energy is dissipated by sets of energy absorbers, which are arranged in the seat-cushion frame and are tautly, less tautly and/or loosely connected to the buckle assembly.
- A single seat can be equipped with holder for persons (adults and/or children) of different ages related to weight groups, which depend on the appropriate sets of energy absorbers. The sets of energy absorbers and/or energy absorbers have different threshold values. Owing to these features the survival chance of the passengers is enhanced and the seats, equipped therewith, can be modified to be used by adults or children, thus increasing the rate of seat occupancy in a train, bus or an aeroplane, exemplified in **Fig. 14**.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15 A number of embodiments, other advantages and features of the present invention will be described in the accompanying tables and drawings with reference to the xyz global coordinate system:

20 **Fig. 1** is a side view a 7th embodiment of a rotatable shoulder holder **10e**, equipped with energy absorbers **10.3**, **40e** and **40f**, rotated by a 2nd embodiment of a rotatable device **28a** from a resting position **P** to an operative position **P<sub>1</sub>**.

Fig. 2 is a perspective view of a restrained dummy, thrown forward in an offset crash test [1].

Fig. 3 is a perspective view of a 1st embodiment of a half of an insertable shoulder- and neck holder **10** equipped with a set of energy absorbers **10.3**, **10.5** and latch plate **10.1**.

25 Fig. 4 is a schematic, perspective view of a 2nd embodiment of an insertable shoulder- and neck holder **10a** equipped with a wider chin-supporting neck collar **10.4a**, energy absorbers **10.3a**, **10.5a** and latch plates **10.1f**.

Fig. 5 is a schematic view of a 3rd embodiment of a half of an insertable shoulder- and neck holder **10b** equipped with the energy absorbers **10.3**, **10.5**, **10.9**.

30 Fig. 6 is a schematic view of a 4th embodiment of an insertable shoulder- and neck holder **10c** equipped with energy absorbers.

**Fig. 7** is a schematic view of a 5th embodiment of a half of an insertable shoulder- and neck holder **10f**, equipped with a latch plate **10.1f** in plug-in connection with a buckle assembly **4b**.

**Fig. 8** is a perspective view of a 6th embodiment of a half of a rotatable shoulder holder **10d**, 5 rotated by a 1st embodiment of a rotatable device **28** from a resting position P to an operative position **P<sub>1</sub>**.

**Fig. 9** illustrates a total load „F<sub>n</sub>”, absorbed by the restraint system in co-operation with an energy-absorbing, vibration-dampening device, in the event of a real-world accident.

**Fig. 10** is a schematic, perspective view of a 1st embodiment of a set of energy absorbers **30**, 10 **40e**, **40f**.

**Fig. 11** is a schematic, perspective view of a 2nd embodiment of a set of energy absorbers **40**, **40e**, **40f**.

**Fig. 11a** is a partially enlarged perspective view of a clamping element with sites of predetermined fracture „s” and both heads of a stop pin to block the clamping element.

**Fig. 12** is a schematic, perspective view of a 3rd embodiment of a set of energy absorbers **50**, 15 **40e**, **40f**.

**Fig. 13a** is a schematic, perspective view of a 1st embodiment of a buckle assembly **4a** comprising a guide piece **4.7a**, release cable **4.2**, tie band **1.1a** and coupling member **1.2a**.

**Fig. 13b** is a schematic, perspective view of a 2nd embodiment of a buckle assembly **4b** 20 comprising a guide piece **4.7b**, an electrical motor **4.2b**, a tie band **1.1b** and coupling member **1.2b**.

**Fig. 13c** is a cross-sectional view of a 3rd embodiment of a buckle assembly **4c** comprising two tie bands **1.5**, **1.6** along the line II-II of **Fig. 13d**.

**Fig. 13d** is a cross-sectional view of buckle assembly **4.8c**, adjustable along the width of the 25 back rest, having two holes to loosely guide two tie bands **1.5**, **1.6**.

**Fig. 14** is a front view of safety seats **85a** to **85e**, **86**, into which the seat belts **1a** to **1e**, sets of energy absorbers, shoulder holders **10**, **10a**, **10b**, **10d**, **10e** and seats **3a** to **3e** are integrated, for passengers with different weights and body proportions.

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## DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The advantages of the preferred embodiments, above-mentioned in the Chap. "Summary of the advantages...", are outlined hereinafter with regard to the functions and features thereof.

The method of the present invention in co-operation with a seat belt capitalizes on the premise that the total energy (magnitude of energy) is subdivided (Fig. 9), at the best, into a 5 number of subenergies which are released in excess of the respective injury-irrelevant values, pursuant to the energy-absorbing method, above-mentioned. This will be apparent by formulating all forces (Fig. 1), imposed on the torso 95.2 and head 95.1 of the passenger, in the event of a real-world accident where the torso, both shoulders and neck of a passenger are restrained by the shoulder- and neck holder and three-point or multi-point seat belt and the 10 energy of two masses of the torso and head are absorbed by the energy-absorbers thereof. The features are applicable for any motor vehicle, provided with arbitrary post sections (pillars), train or aeroplane.

In the 1st to 7th embodiment the shoulder- and/or neck holder 10, 10a to 10f, shown in Figs. 1, 3 to 8, comprises

15 – one- or two-piece caps 10.2, 10.2a to 10.2f with the shoulder-shaped energy absorbers 10.3, 10.3a and/or – one- or two-piece caps 10.4, 10.4a to 10.4c, 10.4f with the neck-shaped energy absorber 10.5, 10.5a, 10.5c.

Two-piece caps of the shoulder holder have an advantage over a one-piece cap of the shoulder 20 holder that it can be put into use for a passenger with two different shoulders. The problem of the one-piece cap of the shoulder holder can only be resolved by the use of two different shoulder energy absorbers.

The cap of shoulder- and neck holder 10, 10b (Figs. 3 and 5) is built by inserting a pair of neck-caps 10.4, 10.4b into a pair of shoulder-caps 10.2, 10.2b. This feature makes the design 25 of the neck caps, insertably attachable thereto as well as detachable therefrom, possible.

Thanks to such design the passenger can decide for the use of the neck caps. If he or she is born with a weak neck muscle, the pair of neck-caps must be insertably attached thereto. On a hot day the neck caps can be removed therefrom. However, for children and persons, having very weak neck muscle, in particular when suffering from cervical trauma, the neck-shaped cap 30 10.4a of holder 10a is recommended. Its wider chin-supporting energy absorber 10.5a (Fig. 4) improves the properties of bracing the head and substantially absorbing energy during the forward motion of the passenger.

To restrain the shoulders and neck of a passenger, the one-piece holder **10a**, in closed form and using a connecting cap **10.11**, has the greatest stiffness, however by removing that connecting cap the holder **10c** in open form does not block out air flow. This controversy is resolved by the stiff rotatable device **28, 28a** of rotatable holder **10d, 10e** in the different 5 embodiments.

The latch plate **10.1** is pivotally attached to the flange **10.12** of shoulder- and neck holder **10** by pin **10.6** or by bolt **10.6a** and nut **10.6b**. The adjustment to the shoulder shape is done by rotating the bolt **10.7** in threaded hole of flange **10.12**. Finally, that bolt is secured by nut **10.8**. Time is greatly consumed for the removal of the belt from the closed apertures of cap **10.2** and 10 the latch plate **10.1**, to loosely guide the belt portion **1.1**, in order to store the holder. Thanks to the open aperture **10.14** of cap **10.2b, 10.2c, 10.2f** and open aperture of latch plate **10.1b**, the belt, when strapped over the holder, can be loosely locked, guided by quick-release pin **10.10** and released by withdrawal of quick-release pin.

In the 5th embodiment ref. to **Fig. 7** the latch plate **10.1f** is secured to the flange **10.12f** by 15 pin **10.6**, bolt **10.6a** and nut **10.6b**. By rotation of bolt **10.6a** in the threaded hole of flange **10.12f**, the cap **10.2f** can be moved along the width of the seat backrest.

In the 1st or 2nd embodiment ref. to **Figs. 1 and 8** each of the pair of casings **29, 29a**, form-locking connected to each other, of rotatable device **28, 28a** of holder **10d, 10e** consists of two outer tubes

- 20 – **28.1, 28.2**, force-locking connected with the coupling wall **28.3**, and an L-shaped plate **28.4**, or
- **41e, 41f**, force-locking connected with the coupling wall **28.3**, and an L-shaped, partly laterally closed and partly laterally open plate **28.4a**.

The end of each rotatable lever **28.5, 28.5a** is loosely guided between plate **28.4, 28.4a** and 25 coupling wall **28.3**. The first ends of both rotatable levers are connected to each other by shaft **28.7**. The cap **10.2d, 10.2e** and release cam **28.6, 28.6a** are fastened to the second end of each rotatable lever. In resting position each cap is located in the seat backrest or on its upper portion, if necessary, underneath the head rest **3.6a**. If a supporting tube **3.61** is available, the cap, recessed about that supporting tube, must be reinforced by reinforcing plate **10.13**.

30 Because the outer tubes **28.1, 28.2** or **41e, 41f** are guided by inner tubes **71, 72** of seat backrest frame **3.4d, 3.4e**, the height of the casings is adjusted in the direction of arrow „U”

(Figs. 1, 8) by manual operation or by a drive apparatus **80** e.g. hydraulic-piston cylinder unit, electrical motor (not drawn), similar to **4.2b** shown in Fig. 13b.

The drive apparatus **80** can be activated by a switch, release button, controller, sensor or an accelerator pedal in reference to one of the Claims 7 to 10. Upon e.g. tipping the switch or

5 release button the drive apparatus moves the holder **10d**, **10e** back to the resting position.

For the convenience of the passenger stepping out of the vehicle or in cases of emergency all latch plates of the seat belt are disengaged and the drive apparatus moves the holder **10d**, **10e** back to the resting position when depressing the master release button **84** of lap buckle assembly **9.1** (Fig. 14).

10 Due to the rotation of both rotatable levers **28.5**, **28.5a**, operated manually or by drive apparatus **80**, both release cams **28.6**, **28.6a** force the rotation of the lock pawls **28.8**, **28.8a**, pre-loaded (biased) by first springs **28.10**, **28.10a**, thereby permitting the locking pins **28.12**, pre-loaded by second springs **28.13**, and loosely guided in guide tubes **28.11**, to move into the holes **28.14** and block the rotatable levers

15 – **28.5** in both directions or  
– **28.5a** in one direction.

When blocked, the loads in the event of rollover, yawing and/or turbulence-related vibration are reduced by the deformable holder **10d**, **10e** equipped with energy absorbers **10.3**. The position of each guide tube **28.11** at the coupling wall **28.3** is denoted by the hole **28.14**. From 20 the operative position  $P_1$  to the resting position  $P$  both rotatable levers **28.5**, **28.5a** snap into the stop pieces **28.9**, **28.9a** and are retained thereby.

The belt portion **1.1**, **1.2** is loosely guided by U-shaped plate **10.15**, similar to **10.14**, of cap **10.2e** and, if necessary, loosely locked by quick-release pin **10.10** (Fig. 5).

In another energy-absorbing embodiment, the long outer tubes **41e**, **41f**, serving as retaining 25 elements and girders, are parts of seat backrest frame **3.4d**, **3.4e** and energy absorbers **40e**, **40f** having clamping elements **42e**, **42f**, which are tightly, less tightly and/or loosely connected to the pair of rotatable levers **28.5a** via the stop pieces **28.9a**, serving as deflectors, by wires **47e**, **47f** in order to determine the onset of energy-absorption. Due to the forward motion of the dotted-line torso **95.2** and head **95.1** each dotted-line rotatable lever **28.5a** with cap **10.2e** is 30 rotated to the position  $P_2$  through the opening of L-shaped, partly laterally-closed and partly laterally-open plate **28.4a**, during which the work of deformation and friction is achieved by the deflection of the dotted-line clamping elements **42e**, **42f** along the respective retaining

elements **41e, 41f**. The stored energy is released in excess of the yield strength and/or of the threshold values. Additional clamping elements **32, 32.1 to 32.n, 42, 42.1 to 42.n, 52, 52.1 to 52.n** can be arbitrarily arranged or be series-connected to clamping element **42e, 42f** to absorb great energy and dampen strong vibrations.

5 In the 1st embodiment the set of vibration-dampening energy absorbers **30, 40e, 40f** (Fig. 10) comprises a retaining element **31**, control-wire **37**, control-clamping element **32** and complementary clamping elements **32.1 to 32.n** (not drawn). After projecting through or into the cylinder-shaped edges **37c1** of control-clamping element **32**, both end portions of complementary wire **37a1** of control-wire **37** are secured by clamping two brackets **37b1** or 10 both cylinder-shaped ends **37c1** therewith. The inner diameter „ $d_i$ “ of retaining element **31, 41** is a little larger than the outer diameter „ $d_i$ “ of inner tubes **71, 72**.

In the 2nd embodiment ref. to Figs. 11, 11a the set of vibration-dampening energy absorbers **40, 40e, 40f** comprises a retaining element **41**, control-wire **47**, control-clamping element **42** and complementary clamping elements **42.1 to 42.n**. Owing to taut, less taut and/or loose 15 connection of complementary wires **47.1, ..., 47.n** with the clamping elements **42, 42.1, ..., 42.n**, if necessary by occupying another pair of adjusting holes „ $L_1$  to  $L_e$ “, the onset of each clamping element, biased, is determinable. Owing to arbitrary connection of wires with arbitrary clamping elements the fracture of the clamping elements can be pre-determined in an arbitrary succession. Determinable, too, is the fracture of each clamping element to absorb 20 energy, e.g. by reaming (bulging) the complementary clamping element **42.1, ..., 42.n** in contact with both heads of stop pin or bolt **46.1, ..., 46.n** with both sides of wedge-shaped stop element **41.3** or by fracture in excess of the yield strength when increasingly loaded.

In the 3rd embodiment ref. to Fig. 12 the set of vibration-dampening energy absorbers **50, 40e, 40f** comprises a cone-shaped retaining element **51**, control-wire **57**, control-clamping element **52** and clamping elements **52.1, .., 52.n** and **53.1, .., 53.n** (not-shown). Both ends of complementary wire **57a1** of control-wire **57** are secured to a control-clamping element **52** by 25 rivets **57b1**.

The load-deflection area is achieved progressively or arbitrarily by the expansion of cone-shaped clamping element **52, .., 52.n, 53, ..., 53.n** along 30

- the cone-shaped retaining element **51** and/or
- the longitudinal rib **51.1** whose thickness longitudinally increases.

The space in the seat backrest and -cushion is exploited to accommodate a number of sets of energy absorbers, having different threshold values for baby, child, adult, old woman and man, which are connected to the shoulder- and/or neck holder and buckle assemblies, whereto the latch plates of, preferably, the multi-point, one-piece seat belt of the seat **3a** to **3d**, shown in **Fig. 14**, are plug-in connected. In a real-world accident this energy-absorbing, vibration-dampening device, operating without sensors, but with the multi-point, one-piece seat belt gradually absorbs great energy below the injury-related values and dampens vibrations. In comparison with the energy-absorbing management device, monitored by the three-sensor mechanisms, aforementioned and proposed by US 5,544,918, the operation is more reliable, the injury severity is substantially lower, the manufacturing costs are far lower and there is neither recall programs nor court-cases.

In the 1st and 2nd embodiment of the buckle assembly **4a**, **4b** (**Figs. 13a** and **13b**), to receive latch plate **2**, **11**, **25**, the one-piece guide piece **4.7a**, **4.7b** is provided with a recess **4.5a** or longitudinal groove **4.5b** to loosely guide tie band **1.1a**, **1.1b**, having coupling member **1.2a**, **1.2b**, to which the wires of sets of energy absorbers **30**, **40**, **50** are tautly, less tautly and/or loosely connected.

After the insertion, in the direction of double arrow, of a pair of engaging parts **4.10a**, **4.10b** of guide piece **4.7a**, **4.7b** in the apertures of the housing **4.8a**, **4.8b** of buckle assembly **4a**, **4b** the clamping parts **4.12** snap into the clamping holes **4.13**.

When the latch plate is pulled under the load of „ $\Delta F_1$  - 500 N”, less than the starting threshold value „ $\Delta F_1$ ”, the buckle assembly, clamping element/s and energy absorber/s move about the deflection „ $T_F$ ” (not drawn). In the state of non-deformation the housing **4.8a**, **4.8b** with/without clamping parts **4.12** must be pulled back into the engaging parts **4.10a**, **4.10b**. This is possible, when „ $T_L$ ” is at least as long as „ $T_s + T_F$ ”. Experiment can clarify, whether the clamping parts and clamping holes are needed. However, the clamping assemblies have the advantage of exactly positioning the buckle assembly in the seat backrest or -cushion. Due to the restriction for the depth „ $T$ ” of seat backrest or -cushion (**Fig. 14**) the length „ $T_L$ ” of engaging parts **4.10a**, **4.10b** is restricted too, hence, the following countermeasures are required:

– When the buckle assembly under load of great impact energy moves along the engaging parts, the tie band **1.1a**, **1.1b** must be guided by the guide piece **4.7a**, **4.7b**, fastened to the seat frame;

- In order to exploit the depth „T”, the length „T<sub>Z</sub>” of latch plate and/or the length „T<sub>L</sub>” of engaging parts **4.10a, 4.10b** is/are increased;
- By not using guide piece the wires of sets of energy absorbers can tautly, less tautly and/or loosely be connected to couple member **1.2a, 1.2b** or an end of the seat belt; and/or
- 5 – Owing to biasing at least one control-clamping element **32, 42, 52** at „ΔF<sub>1</sub> - 500 N” the housing can only move in excess thereof for the purpose of undampened energy-absorption.

In the 3rd embodiment of the buckle assembly **4c** (Fig. 13c), to receive latch plate **2, 9, 11, 25**, the housing **4.8c**, that can be moved along a pair of tube **27.3** of the frame of seat backrest or seat cushion and latched thereon, are provided with two holes **4.5c** to loosely guide tie bands **1.5, 1.6**, having couple members **1.2a, 1.2b**. A wire is projected through the hole **2.3** of buckle assembly **4c**. Both end portions, serving as tie bands **1.5, 1.6**, are secured by a mutual bracket **1.7**. The engaging part **4.10c** of buckle assembly **4c** is in pig-tail- or form-locking connection to an aperture of housing **4.8c**. Large height- and width-adjustment can result in slackness and inaccuracy when biasing the wires. Such shortcoming is resolved by directly 10 attaching the sets of energy absorbers to the parts (not drawn) of the height- and width-adjustable mechanism.

The buckle assemblies **4a, 4b, 4c**, having the release cable **4.2**, the electrical motor **4.2b** with a shaft **4.3b** and release cable **4.3**, are suited for buckle assemblies **4, 7, 8, 8a, 9.1, 18a / 19a to 18n / 19n** of the seats **3a to 3c** (Fig. 14). When the release cables **4.2** or **4.3** of the buckle 20 assemblies are connected to the master release button **84** of lap buckle assembly **9.1** (Fig. 14) the depressing the master release button **84** results in disengaging of all latch plates of the seat belt and holder **10, 10a to 10c, 10f** therefrom. This one-click operation increases the convenience of the passenger, when stepping out as well as facilitates the quick-rescue of the injured passenger in accidents.

25 Thanks to plug-in connection of at least one anti-submarining latch plate **11, 25**, movable along the lap belt portion **1.3**, with an anti-submarining buckle assembly **7, 8, 8a** of the seat cushion (Fig. 14), provided with sets of energy absorbers, the energy, imposed on both thighs, in the event of submaring and/or rollover is absorbed and released by fracture of the sites of predetermined fracture. To properly restrain both thighs of a child, sitting on the seat **3a**, three 30 movable anti-submarining latch plates **11, 25** are in plug-in connection with the respective anti-submarining buckle assemblies **7, 8a**. So a safety child-seat **85a, 85b** is created by integration the seat belt, energy absorbers and holder into the seat itself.

Another application results from direct conversion of a child-seat 85a into

- a baby-cot 86 by flipping the seat backrest 3.2a into a baby-resting position or
- a safety adult-seat 85a by disconnecting the movable latch plates 25 from the anti-submarining buckle assemblies 8a, repositioning the seat backrest to an adult-seating position and mounting the holder 10a back into the cutaway of the seat cushion.

5 Thanks to the multi-purpose of energy-absorbing, vibration-dampening safety seat a high rate of seat occupancy in an aeroplane can be achieved and there is no need for purchasing child-seats and baby-cots, administrating, storing and transporting them anymore.

For safety reasons and easy access the latch plates 25, when not being used, are stored in a 10 storage box 25.2 (Fig. 14). The belt-detachable latch plates 25, each having a quick-release pin 25.1 (similar to 10.10 shown in Fig. 5), are attached to any belt portion 1.1, 1.2, 1.3 when needed (Fig. 14).

15 Notably, any passenger of any age, body proportion and weight is protected from severe/fatal injury by the energy-absorbing device incorporated with the multi-point seat belt and insertable or rotatable attachment of the shoulder- and/or neck holder 10, 10a to 10f to the seat backrest frame.

20 Lack of functional tests to determine the permeability, stiffness and design of the caps and properties of energy-absorption it is necessary to design a number of holders to restrain the upper part of body 95 of a passenger (dummy), restrained, preferably, by the multi-point seat belt, in order to determine the cheapest design characterized by the best mode to reduce all acceleration-dependant forces, dampen vibrations and avoid whiplash in crash tests.

25 Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended claims, the present invention may be practised otherwise than as specifically described and illustrated.

What is claimed:

1. A restraint system equipped with a shoulder holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence, comprising  
5 a seat belt (**1d, 1e**), consisting of several belt portions, at least one latch plate, a buckle assembly, a belt pretensioner and belt fittings;  
a shoulder holder (**10d**), having a pair of shoulder caps (**10.2d**), which, when in a resting position, are located in a seat backrest (**3.2d, 3.2e**); and  
10 a manually-operated rotatable device (**28**), having a pair of rotatable levers (**28.5**), retained by stop pieces (**28.9**) in the resting position, where the rotatable levers (**28.5**), having first ends, connected to the pair of shoulder caps (**10.2d**), and second ends, connected to each other by a shaft (**28.7**), are rotatably attached to a pair of casings (**29**), each of which, defined by an L-shaped plate (**28.4**) and two outer tubes (**28.1, 28.2**), connected to each other by a coupling wall (**28.3**), is height-adjustable, latchable and guided by inner tubes  
15 (**71, 72**) of a seat backrest frame (**3.4d, 3.4e**);  
wherein  
a passenger is restrained by the seat belt (**1d, 1e**) and his shoulders are restrained by the shoulder caps (**10.2d**), moved by the rotatable device, manually-operated, from the resting position to an operative position;  
20 where at least one shoulder belt portion of the seat belt (**1d, 1e**) is extended over the respective shoulder cap and a U-shaped plate (**10.15**) thereof, when the rotatable levers (**28.5**) are manually rotated, causing release cams (**28.6**) of the rotatable levers to force a rotation of lock pawls (**28.8**), pre-loaded by first springs (**28.10**), thereby permitting locking pins (**28.12**), pre-loaded by second springs (**28.13**) and loosely guided in guide tubes (**28.11**), to move into holes (**28.14**) of the casings (**29**) and block the rotatable levers  
25 in both directions.  
2. A restraint system equipped with a shoulder holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence, comprising  
a seat belt (**1, 1e**), consisting of several belt portions, at least one latch plate, a buckle  
30 assembly, a belt pretensioner and belt fittings;  
a shoulder holder (**10e**), having a pair of shoulder caps (**10.2e**), which, when in a resting position, are located on an upper portion of a seat backrest (**3.2d, 3.2e**); and

a motor-driven rotatable device (28a), having a drive apparatus (80) and a pair of rotatable levers (28.5a), having first ends, connected to the pair of shoulder caps (10.2e), and second ends, connected to each other by a shaft (28.7), are rotatably attached to a pair of casings (29a), each of which, defined by an L-shaped, partly laterally closed and partly laterally open plate (28.4a) and two outer tubes (41e, 41f), connected to each other by a coupling wall (28.3), is height adjustable, latchable and guided by inner tubes (71, 72) of a seat backrest frame (3.4d, 3.4e); and

5 vibration-dampening energy absorbers (40e, 40f), having a number of clamping elements (42e, 42f) provided with sites of predetermined fracture (s), biased, arranged along the outer tubes (41e, 41f) and tautly, less tautly and/or loosely connected to the pair of rotatable levers via stop pieces (28.9a) by corresponding wires (47e, 47f);

10 wherein

a passenger is restrained by the seat belt (1, 1e) and his shoulders are restrained by the shoulder caps (10.2e), moved by the rotatable device, driven by the drive apparatus (80), from the resting position to an operative position;

15 where at least one shoulder belt portion of the seat belt (1, 1e) is extended over the respective shoulder cap and a U-shaped plate (10.15) thereof, when the rotatable levers (28.5a) are rotated by the drive apparatus (80), causing release cams (28.6a) of the rotatable levers to force a rotation of lock pawls (28.8a), pre-loaded by first springs (28.10a), thereby permitting locking pins (28.12), pre-loaded by second springs (28.13) and loosely guided in guide tubes (28.11), to move into holes (28.14) of the casings (29a) and block the rotatable levers in one direction;

20 where in the real-world accident or in the inflight turbulence a forward motion of the torso and head rotates the rotatable levers in another direction through the openings of the L-shaped, partly laterally closed and partly laterally plates (28.4a), thus moving the clamping elements (42e, 42f) along the corresponding tubes (41e, 41f) resulting in a work of deformation and friction, during which vibrations are damped and a stored energy is released by fracture of the sites of predetermined fracture of the clamping elements in excess of respective threshold values.

25 30 3. A restraint system equipped with a shoulder holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence, comprising

a seat belt (**1, 1b, 1e**), consisting of several belt portions, at least one latch plate, a buckle assembly, a belt pretensioner and belt fittings;

a shoulder holder (**10, 10b, 10f**), having a pair of shoulder caps (**10.2, 10.2b, 10.2f**) with open apertures to receive the belt portions;

5 a pair of latch plates (**10.1b**), connected to the shoulder caps (**10.2, 10.2b, 10.2f**), with open apertures, in which the belt portions are loosely secured by quick-release pins (**10.10**), when the shoulder holder and the seat belt are fitted together, and released by withdrawal thereof for removal, when the shoulder holder is withdrawn; and

at least one pair of buckle assemblies (**18a / 19a to 18n / 19n**), attached in a seat backrest

10 (**3.2a, 3.2c**);

wherein

a passenger is restrained by the seat belt (**1, 1b, 1e**) and his shoulders are restrained by the shoulder caps (**10.2, 10.2b, 10.2f**) upon plug-in connection of the latch plates (**10.1b**) with the buckle assemblies (**18a / 19a to 18n / 19n**); and

15 at least one shoulder belt portion of the seat belt (**1, 1b, 1e**) is extended over the open aperture of the corresponding shoulder cap and loosely secured in the open aperture of the latch plate.

4. A restraint system equipped with a shoulder- and neck holder to increase survival chance in a real-world accident of a vehicle, train or an aeroplane or in an inflight turbulence,

20 comprising

a seat belt (**1a, 1c, 1e**), consisting of several belt portions, at least one latch plate, a buckle assembly, a belt pretensioner and belt fittings;

a one-piece shoulder- and neck holder (**10a, 10c**), defined by a neck cap (**10.4a, 10.4c**) and a shoulder cap (**10.2a, 10.2c**) with open apertures to receive the belt portions;

25 a pair of latch plates (**10.1b**), connected to the shoulder cap (**10.2a, 10.2c**), with open apertures, in which the belt portions are loosely secured by quick-release pins (**10.10**), when the one-piece shoulder- and neck holder and the seat belt are fitted together, and released by withdrawal thereof for removal, when the one-piece shoulder- and neck holder is withdrawn; and

30 at least one pair of buckle assemblies (**18a / 19a to 18n / 19n**), attached in a seat backrest (**3.2a, 3.2c**);

wherein

a passenger is restrained by the seat belt (**1a, 1c, 1e**) and his shoulders and his neck are restrained by the shoulder cap (**10.2a, 10.2c**) and neck cap (**10.4a, 10.4c**) upon plug-in connection of the latch plates (**10.1b**) with the buckle assemblies (**18a / 19a to 18n / 19n**); and

5 at least one belt shoulder portion of the seat belt (**1a, 1c, 1e**) is extended over the corresponding open aperture of the shoulder cap and loosely secured in the open aperture of the respective latch plate.

5. The restraint system according to claim 2, wherein the shoulder cap (**10.2e**), recessed about a supporting tube (**3.61**) of a head rest (**3.6**), is reinforced by a reinforcing plate (**10.13**).

10 6. The restraint system equipped with a shoulder- and neck holder according to claim 2, further comprising a neck holder, having a pair of neck caps (**10.4, 10.4b**), attached to the pair of shoulder caps (**10.2e**), to restrain the passenger's neck in the operative position.

7. The restraint system according to claim 6 wherein the drive apparatus (**80**) is activated by a separately operated switch.

15 8. The restraint system according to claim 6, wherein the drive apparatus is activated by a controller, monitoring the speed, in excess of a threshold speed.

9. The restraint system according to claim 6, wherein the drive apparatus is activated by an accelerator pedal.

20 10. The restraint system according to claim 6, wherein the drive apparatus is activated when a sensor senses an acceleration, which exceeds a threshold acceleration.

11. The restraint system according to claim 6, wherein upon a pressure on a release button (**87a to 87c**) of the seat the drive apparatus (**80**) moves the shoulder- and neck holder back from the operative position to the resting position.

25 12. The restraint system according to claim 6, wherein the lap buckle assembly (**9.1**) has a master release button (**84**), which is connected to switches of the drive apparatus (**80**) and electrical motors (**4.2b**) of the remaining buckle assemblies of the seat belt via respective deactivating cables, where the master release button (**84**), when depressed, disengages all the latch plates and moves the shoulder- and neck holder back from the operative position to the resting position.

13. The restraint system equipped with a shoulder- and neck holder according to claim 3, further comprising

a neck holder, having a pair of neck caps (10.4, 10.4b), insertably attached to the pair of shoulder caps (10.2, 10.2b, 10.2f), to restrain the neck upon use,

5 where the neck caps can be detached therefrom and removed.

14. The restraint system according to claim 13, wherein the shoulder- and neck holder (10, 10b, 10f) is provided with at least one energy absorber (10.3, 10.3a, 10.5, 10.5a, 10.5c).

15. The restraint system according to claim 14, wherein the energy absorber is fastened to the cap by an adhesive fastener and detachable therefrom by opening the fastener.

10 16. The restraint system according to claim 3, wherein the shoulder cap is shoulder-shaped.

17. The restraint system according to claim 14, wherein the energy absorber is shoulder-shaped.

18. The restraint system according to claim 13, wherein the neck cap is neck-shaped.

19. The restraint system according to claim 14, wherein the energy absorber is neck-shaped.

15 20. The restraint system according to claim 19, wherein the energy absorber (10.5a), arranged in the neck cap (10.4a), serves as a neck collar having a wide portion for the chin.

21. The restraint system according to claim 3, wherein the latch plate of the holder is provided with an energy absorber (10.9).

20 22. The restraint system according to claim 13, wherein the shoulder- and neck cap, provided with a flange (10.12), is adjustable in height by rotating a bolt (10.7) in a threaded hole of the flange (10.12).

23. The restraint system according to claim 13, wherein the shoulder- and neck cap, provided with a flange (10.12f), is adjustable in width by rotating a bolt (10.6a) in a threaded hole of the flange (10.12f).

25 24. The restraint system equipped with the shoulder- and neck holder and with vibration-dampening energy absorbers according to claim 13, further comprising at least one vibration-dampening energy absorber (30, 40, 50), which consists of

a retaining element (31, 41, 51), serving as a member of a seat frame, generally representing a seat-cushion- or seat backrest frame, and

at least one clamping element (32, 32.1 to 32.n, 42, 42.1 to 42.n, 52, 52.1 to 52.n),  
5 connected to the buckle assembly of the seat by means of at least one control-wire (37, 47,  
57), biased, arranged along the retaining element and provided with sites of predetermined  
fracture (s), which have at least one threshold value.

25. The restraint system according to claim 24, wherein the retaining element is integrated  
into the seat frame.

26. The restraint system according to claim 24, wherein the clamping element has open and  
10 tube-shaped profile.

27. The restraint system according to claim 24, wherein the retaining element is tube-shaped.

28. The restraint system according to claim 24, wherein a longitudinal rib (41.1, 51.1) is  
arranged to the retaining element.

29. The restraint system according to claim 28, wherein both edges of the clamping element  
15 are loosely guided by the longitudinal rib in longitudinal direction.

30. The restraint system according to claim 28, wherein a stop element (41.3) is arranged to  
the longitudinal rib.

31. The restraint system according to claim 28, wherein the thickness of the longitudinal rib  
increases in longitudinal direction, in which the clamping element moves.

20 32. The restraint system according to claim 24, wherein the clamping element is cone-shaped.

33. The restraint system according to claim 24, wherein the retaining element (51) is cone-  
shaped.

25 34. The restraint system according to claim 24, wherein at least one stop pin (46, 46.1 to  
46.n) is laterally arranged to the retaining element, where the stop pin blocks a movement of  
the clamping element, thus resulting in fracture of the sites of predetermined fracture.

35. The restraint system according to claim 24, wherein contact surfaces of the retaining  
element have arbitrary friction coefficients ( $\mu_0$ ).

36. The restraint system according to claim 24, wherein contact surfaces of the retaining element are provided with a soundproofing material (83).

37. The restraint system according to claim 24, wherein contact surfaces of the clamping element have arbitrary friction coefficients ( $\mu_0$ ).

5 38. The restraint system according to claim 24, wherein contact surfaces of the clamping element are provided with a soundproofing material (83).

39. The restraint system according to claim 29, wherein end portions of a complementary wires (37a1), connected to the control-wire (37), are inserted into both cylinder-shaped edges (37c1) of the clamping elements (32) and secured by clamping the cylinder-shaped edges 10 (37c1).

40. The restraint system according to claim 24, wherein the clamping element is provided with a pair of ribs, whereto several pairs of adjusting holes ( $L_1$  to  $L_e$ ) are arranged.

41. The restraint system according to claim 24, wherein a set of vibration-dampening energy absorbers comprises the retaining element, at least one stop pin, at least one stop element, one 15 control-clamping element, connected to the control-wire, and complementary clamping elements with/without sites of predetermined fracture, where all clamping elements, arranged along the retaining element, are tautly, less tautly and/or loosely connected to each other by means of complementary wires.

42. An energy-absorbing, vibration-dampening device according to claim 41, comprising a 20 couple member (1.2a, 1.2b) and the sets of vibration-dampening energy absorbers, the control-wires of which are tautly, less tautly and/or loosely connected to the couple member.

43. The restraint system according to claim 42, wherein a guide piece (4.7a), fastened to the seat frame, has

a pair of engaging parts (4.10a), form-locking connected to the corresponding apertures of a 25 housing (4.8a) of the buckle assembly; and

a recess (4.5a) to loosely guide a tie band (1.1a), having a first and second end connected to the buckle assembly and the couple member.

44. The restraint system according to claim 42, wherein a guide piece (4.7b), fastened to the seat frame, has

a pair of engaging parts (4.10b), form-locking connected to the corresponding apertures of a housing (4.8b) of the buckle assembly; and

a longitudinal groove (4.5b) to loosely guide a tie band (1.1b), having a first and second end connected to the buckle assembly and the couple member.

5        45. The restraint system according to claim 42, wherein a housing (4.8c), movable along a pair of tubes (27.3) of the seat backrest frame and latchable thereon, has an aperture to receive an engaging part (4.10c) of the buckle assembly, through a hole (2.3) of which a wire is protruded and both end portions of the wire, serving as tie bands, are secured by a mutual bracket (1.7); and

10      two holes (4.5c) to loosely guide the tie bands, connected to the couple members.

46. An anti-submarining seat-belt assembly to absorb energy and dampen vibrations in the real-world accident, a rollover or the turbulence-related vibrations according to claim 43, wherein the lap belt portion (1.3) of the seat belt (1d, 1e), provided with at least one movable anti-submarining latch plate (11, 25), is subdivided into two anti-submarining belt portions; 15      which restrain both thighs of the passenger upon plug-in connection of the movable anti-submarining latch plate (11, 25) with one of anti-submarining buckle assemblies (7, 8, 8a) of a seat cushion, whose frame is equipped with the guide pieces (4.7a) and the energy-absorbing, vibration-dampening device; where release cables (4.2) connect release buttons of the submarining buckle assemblies to a 20      common release button (840), located on the seat cushion, which, when depressed, disengages the movable anti-submarining latch plate (11, 25) while the restraint of the belted passenger remains unaffected.

47. The restraint system according to claim 13, wherein the lap buckle assembly (9.1) has a master release button (84); 25      which is connected to release buttons of the remaining buckle assemblies of the seat belt and to release buttons of the pairs of buckle assemblies, to one of which the latch plates of the holder are plug-in connected; where the master release button (84), when depressed, disengages all the latch plates of the holder and seat belt.

**48.** The restraint system according to claim 3, wherein the shoulder holder is attached to the seat for the purpose of storage and detachable therefrom by depressing a release button (87a to 87c) of the seat.

**49.** The restraint system according to claim 13, wherein the shoulder- and neck holder is attached to the seat for the purpose of storage and detachable therefrom by depressing a release button of the seat.

**50.** An energy-absorbing, vibration-dampening safety seat according to claim 49, wherein sets of vibration-dampening energy absorbers, the seat belt, holder and seat are integrated into a safety adult-seat;

10 which is transformed into a safety child-seat when a detachable front portion of the seat cushion (3.1a) serves as a shoulder- and neck holder (10a), the latch plates of which are plug-in connected to one of the pairs of buckle assemblies (18a / 19a to 18n / 19n) of the seat backrest, to restrain shoulders and a neck of a belted child and the space thereof is exploited to accommodate legs of the child sitting on the rear portion thereof;

15 where the safety child-seat can be converted back into the safety adult-seat.

**51.** An energy-absorbing, vibration-dampening safety baby-cot according to claim 50, wherein

the safety child-seat is transformed into a safety baby-cot when the seat backrest is flipped downwards;

20 where the safety baby-cot can directly be converted back either into the safety child-seat or into the safety adult-seat.

**52.** The restraint system according to claim 46, wherein the lap buckle assembly (9.1) has a master release button (84),

25 which is connected to release buttons of the remaining buckle assemblies of the seat belt and to release buttons of the pairs of buckle assemblies, to one of which the latch plates of the holder is plug-in connected, as well as to the release buttons of the anti-submarining buckle assemblies,

where the master release button (84), when depressed, disengages the movable anti-submarining latch plate and all the latch plates of the holder and seat belt.

## ABSTRACT

A shoulder- and/or neck-holder, seat-belt, seat and sets of vibration-dampening energy-absorbers are integrated into an energy-absorbing, vibration-dampening safety-seat in order to

5 restrain the shoulders and/or neck of a belted passenger, dampen vibrations and gradually absorb subenergies, resulting from a subdivision of the total energy, just below the respective injury-irrelevant threshold-values in any real-world accident of a transport-system, submarining or during in-flight turbulence. The conversion of an adult-seat into a child-seat or a baby-cot or vice-versa is simple. A rotatable device makes the holder easy to use.

10 Neck- and/or shoulder-shaped, height-, width-adjustable holders and/or neck- and/or shoulder-shaped energy absorbers, attached thereto, ensure complete restraint of the shoulders and necks of passengers with different weights and body-proportions.

For the convenience of the passenger or in cases of emergency all latch-plates are disengaged from the buckle-assemblies and/or the rotatable holder is repositioned to the resting position

15 on depression of a master release-button.

## OTHER PUBLICATIONS

- [1] Car-Magazine ADAC 1/95
- [2] Car-Magazine AMS (Auto Motor und Sport) 23/97
- 5 [3] Car-Magazine AMS 12/99, Newspapers Wiesbadener Kurier of 28.12.98, 20.01, 22.06,  
04.11.99, Frankfurter Allgemeine Zeitung of 08.09.99, Frankfurter Rundschau of 12.06.99
- [4] Wiesbadener Tagsblatt of 28.12.97 reporting 100 injured passengers, 10 of which severely,  
during turbulence-related vibrations of an aeroplane Boeing 747.
- 10 [5] Wiesbadener Tagsblatt of 15.04.99 reporting 30 injured passengers during turbulence-  
related vibrations of an aeroplane Boeing 747.
- [6] Police accident report and photos documenting the steering wheel and -column totally  
deformed by the head, thrown forward, of a 34 years-old driver of a brand-new German  
luxury car.
- 15 [7] Police accident report and accident report by Go documenting the instant death of a 34  
year-old female driver in a German premium sport car, into which a smaller Japanese car  
crashes in the city Wiesbaden, due to the head impact with the window pane and whiplash.
- [8] 34-page accident report by Go concerning severe/fatal injuries, submarining, head impacts  
and whiplash resulted from failure of conventional seat belts etc. to four German  
Ministers, General Attorney, Vice General Attorney, Senior Attorneys, Police Chief  
20 Directors, Police Directors etc.